Decision-making profiles, managerial capacity, management and performance: A study of Costa Rican dairy farmers

by

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I dedicate this work to the memory of my beloved brother

Juan Andrés (1965-1998)

Declaration

I hereby declare that this thesis has been composed by myself, and is the product of my own work.

Signed: Date: April 2, 2000

Abstract

The decision-making process, as the human component of the system, has been either neglected or oversimplified in many ways. This has had negative effects on the development of useful and fully adopted decision-support systems and on the identification of research priorities, recommendation domains, targets and media in technology transfer activities. These weaknesses of the Farming Systems Research and Extension have had negative impact on agriculture. The study of this process seems to be fundamental to overcome the above explained weaknesses by incorporating the human 'block' in the building process that is already taking place within this agricultural science discipline.

The aims to this thesis were: 1-To develop a conceptual model of the decision-making process based of the literature and to identify key issues to be studied. 2-To study the Objectives hierarchies, the decision-making approaches and the Personal Information sources, as components of the process, in terms of factors affecting them and defining the population profiles. 3-Quantify the impact of these decision-making profiles on management and on the bio-economical performance of the farms.

The conceptual model developed showed a very complex decision-making process with multiple components, steps, information flows, actors and activities. Three aspects i.e. Objectives, Decision-making units and Personal information sources, were identified as very relevant to be studied. Results showed that a synergetic affect of age, educational level and the dimension of the farm had the biggest impact on the Objectives hierarchies, Decision-making units and actors involved, and on the preferences towards different personal information sources. In term of Objectives hierarchies, a very high diversity of orientations was found, from the monetary maximisation to familiar and personal orientations, being the former the most frequent. In terms of Decision-making units the results showed that the importance of the units depends, apart form the farmers'/farms' characteristics, on some intrinsic characteristics of the farming decisions and that some very strategic decisions are either delegated or shared with several actors. The steps of the decision-making process affected the information sources used by the farmers, being the family and technical advisors the most preferred personal information sources. Well defined

groups of farmers were identified from the three points of view and clear profiles could be developed as classification. Significant impacts, especially of the decision-making approach and information preference profiles, on management factors were found. Significant impacts of the management factors on the bio-economic performance of the farms were also found as well as direct effects of the information preferences profiles on performance.

General remarks on the implications of the findings obtained on the development of decision-making support systems and on the definition of research priorities, recommendation domains, target and media in technology transfer activities are discussed.

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Chapter 1 Justifying the study of decision-making process

1.1 Introduction

The decision-making process, as the human component of the system, has been either neglected or oversimplified in many ways. This has had negative effects on the development of useful and fully adopted decision-support systems and on the identification of research priorities, recommendation domains, targets and media in technology transfer activities. These weaknesses of agricultural sciences have had negative impact on agricultural development. The study of the decision-making process seems to be fundamental to overcome these weaknesses by incorporating the human 'block' in the building process that is already taking place within this agricultural science discipline.

The aims of the chapter are: 1) to discuss some of the weaknesses of the agricultural sciences and Farming System Research and Extension approach (FSR/E), as an approach, that have diminished its impact on agricultural development; 2) present some of the changes that should take place in order to develop a new paradigm, and 3) to provide the reader with a overview of content and structure of the theses.

1.2 Weakness of agricultural sciences and Farming System Research and Extension

1.2.1 An oversimplified modelling approach

Considerable progress in development of simulation models has been obtained. However, the majority of models have been developed to simulate the biological and financial components of the system (Ferreira, 1997; Dent *et al.* 1994; Dent, 1994; Andison, 1989). This is a result of the better understanding of these components, due to extensive and comprehensive basic research made throughout the years. All this knowledge has been relatively well integrated into simulation models that have proved to satisfactorily predict some of the most important biological and financial processes.

These components have traditionally been considered in higher levels in the hierarchies of research. However, the human component of the system has been either neglected or oversimplified as a consequence of the fact that little knowledge about it exists and it occupies low level in the hierarchy of research priorities.

Other problems faced in the development of models are repetition and overlapping (Dent *et al.* 1994). The former is a result of independent development of models for the same species of crops, for instance. The latter is a result of the lack of integrated use of biological models as building blocks. This problem has lead to a delay in the progress of science in producing agricultural development.

1.2.2 Lack of interface between farmers and scientists

Traditional research and extension programs have been designed to respond to the objectives of the scientist rather than the perspective of the farmers (Dent, 1992; Dent *et al.* 1994). This situation has lead to the development of irrelevant technologies from the point of view of the farmer (Röling, 1994), or the development of non-suitable technologies for specific farms or farm household conditions.

The value of indigenous knowledge has also been underestimated as a generator of technologies (Röling, 1991), formal scientific knowledge has been regarded as the only acceptable (Röling, 1994). Nevertheless, some researchers have recognised the importance and value of farmers as technology generators (Chambers, 1989). Finally it has been demonstrated that the knowledge that is generated by researchers, decision-support systems, for instance are not easily used by the farmers (Dent, *et al.* 1994), showing a lack of a suitable interface between the outcomes of research and the farmer. This could be related to the lack of understanding of the information flows used by farmers and their objectives.

1.2.3 Lack of understanding of the decision making process

Some authors believe that the lack of understanding of the decision-making process is one of the biggest causes of the partial failure of the scientific community to create technologies to solve the biggest problems in agriculture (Dent, 1995; Ferreira, 1997).

The decision-making process has also been over simplified in several ways. Firstly in terms of the decision making unit, it is often assumed that a single person makes decisions concerning farm management. Secondly, in terms of the objectives or goals that motivate the decision-making process, the farmer has been conceptualised as a person acting towards maximisation biological outcomes or profit of the farm (Gasson, 1973; Dent, 1994; Ferreira, 1997; Frank, 1997). This assumption overlooks the fact that other less economic and more social and psychological objectives and values could be driving the decision-making process.

1.3 A new paradigm

Some researchers believe that a new paradigm is necessary to overcome the weaknesses of FSR/E. This paradigm implies the following:

1) A linking of existing biological and financial simulation models (Harrison *et al.* 1990; Dent 1992; Dent *et al.* 1994).
2) An expansion of the system boundary to include socio-economic aspects and their relationship with biological subsystems. This is necessary to increase the power of prediction of whole farm models to evaluate the potential of different technologies (Dent, 1995).
3) A need to include the farmers' point of view in the identification and definition of research priorities (Dent, 1992; 1994).
4) The creation of an interface between the farmers' knowledge and the knowledge created by formal scientific research (Röling, 1994) through the identification of indigenous knowledge, its structures and flows.
5) The study of the farm household as the appropriate decision making unit (Jones, 1967; Dent, 1995; Ferreira, 1997) and attention to the internal and external factors affecting the decision-making process.

In order to develop this new paradigm, more empirical evidence is required to understand the decision-making process and therefore the human component of the system. This research should be carried out from a broad perspective, one that includes all the actors, actions, and information flows that constitute the whole process.

The general aim of this thesis is to provide some empirical evidence and some methodological proposals that contribute to a better understanding of this process.

1.4 Structure of the theses

In chapter 2, a comprehensive literature review of the decision-making process is made, from which an extended conceptual model of this process is constructed. This conceptual model is used to define the hypotheses for empirical testing in this thesis.

Chapter 3 provides some useful information to the reader about the context of the study from the point of view of both farms and farmers. A brief description of Costa Rica and its dairy sector is given, as well as a general characterisation of farms in the sample.

Three important components of the decision-making process are identified in chapter 2 as essential for defining the human component of the system. These were studied as follows:

Chapter 4 provided empirical evidence of the objectives of the farmers, the factors affecting the hierarchies of these objectives, and defines group of farmers (profiles) with similar objective orientations.

Chapter 5 studies who actually makes farming decisions, the factors affecting the level of involvement of different actors in the process, and defines profiles as representative of the decision-making units.

Chapter 6 provides evidence of the role of personal information sources in the different steps of the decision-making process, the factors affecting the preferences of farmers towards different informational sources, and defines the profiles of these preferences.

Once the human component of the system was defined, Chapter 7 integrated all the profiles developed in the previous chapters and investigated the relationships between the profiles and some biographical variables with management practices and farm performance.

In Chapter 8, a general discussion of the results and their implications in terms of research and extension activities is given. Finally, discussion on some limitations of the study's methodology and directions for future research is made.

Chapter 2 Defining a conceptual model of the decision-making process

2.1 Introduction

The last chapter demonstrated that a new paradigm is necessary to increase the impact of agricultural sciences and Farming Systems Research and Extension on agricultural development. This paradigm implies gaining a better understanding of the decision making process as a vital step in order to identify the relevant level of research and ensure higher adoption rates of the technology generated by this discipline of the agricultural sciences.

The objective of this chapter is to present a comprehensive (not exhaustive) literature review of the decision-making process that leads to the definition of the hypotheses to be tested. This covers key references proving concepts and empirical evidence that are used in the development of a conceptual model of the whole process.

2.2 Stages of the Decision-making process

Since decision-making is a dynamic process, which takes place in time and has different stages and different activities in each stage, it is necessary to define its building blocks to build the structure of the conceptual model.

Several authors have developed different conceptual models describing stages comprehending the same activities with a similar chronological sequence. However, they have used a wide variety of terminologies to describe the same groups of activities.

2.2.1 Problem detection or awareness of new practices as catalysts of the decision-making process

The motives by which farmers become engaged in the decision-making process have been identified as: detection of a problem (Jones, 1967; McClymont, 1984; Öhlmér *et al*, 1994; Sipilainen, 1994); a conscious or unconscious reassessment of the farm situation; a desire to improve, or the introduction of a new idea

(McClymont, 1984) or an opportunity (Öhlmér *et al*, 1998). In a re-active way, motivation could be related to events occurring in the decision-maker's environment, which produce a dissonance between this situation and personal satisfaction (Frank, 1995). In other words, decision-making is motivated by a cognitive dissonance as the result of a voluntary or involuntary awareness of an innovation or recognition of a problem. This leads to a need for reducing this mental discontent by decision-making (Jones, 1967).

Problem detection is defined as becoming aware of a difference between the perceived situation, by means of monitoring and an estimation of future consequences, and the desired situation, which is defined by goals. This awareness leads to a dissatisfaction stage (Öhlmér, 1992; Öhlmér *et al,* 1994). In other words problem detection is the result of an assessment between the perceived situation and the desired goals.

According to Öhlmér *et al* (1994) there are two types of farmers in respect to how they detect problems. They are: 'The 'qualitative' who are slow in detecting problems and exhibit a re-active (recognition of the problem by an outside influence) and the 'quantitative' who use a proactive or purposeful problem finding approach thinking creatively about the goals to be achieved using planning and performance monitoring from measurable indicators.

2.2.2 Problem definition

Some authors have defined an intermediate step between problem detection and searching for alternative solutions. In this step, the causes of the problems are identified, (Öhlmér, 1992) and in some cases solved just by reviewing the methods used in the farm (McClymont, 1984). This review occurs in three different levels i.e an internal or personal review, discussion with neighbour/friends, and with specialists. In general, this step leads to a more precise definition of the problem and therefore gives the farmer (when the problem was not solved) the orientation for information seeking that is required in the following step of decision-making.

2.2.3 Searching for solutions to problems or information of the new practices

After the problem detection or awareness of a new practice, which produces a cognitive dissonance, the farmer moves towards a process of information seeking. This includes alternative solutions to the problem (often several) or information about the new practices. This information in turn reduces this psychological status (Frank, 1995; Sipilainen, 1994). The farmer uses his/her information sources e.g. the opinion of leaders or confidants in the farming community, specialists, relevant literature (McClymont, 1984) other experienced farmers, academic staff of a University, extension agents, and technical newsletters (Frank, 1995). Information about the factor affecting the problem and consequences of the alternative solution is also collected (Öhlmér *et al*, 1998).

Within this phase, an adaptive component takes place by which the farmer takes the new information and tries to evaluate or blend it in terms of his/her farming system.

Factors affecting the adoption of new technologies

Because the adoption process is a decision itself, and therefore part of the whole process, it is necessary to spend some time looking at the factors that affect this decision process.

The adoption process is motivated by two causes: 1-when the farmer becomes aware of a new practice or, 2- when, among possible solutions for a problem, one or several new practices are considered. In this process, the farmer evaluates the practices or technologies in the scope of different criteria e.g. cost, satisfaction, prestige, security (Jacobsen, 1994), relevancy and resource availability (Frank, 1995).

The diffusionist approach

The factors affecting the adoption process of innovations were extensively studied by the diffusionist approach (compiled in the work of Rogers, 1983). This approach began with classic references such as the pioneer work of Ryan and Gross (1943) (mentioned by Rogers, 1983) on the adoption process of corn hybrids and others works published between the 40's and the 80's.

According to this approach, the adoption of innovations describes an "S" shape when the cumulative number of adopters is plotted against time. From this curve of adoption, the concept of "take off" was derived. This occurs when around 15% of the potential users, often the opinion leaders, use a new idea. This leads to an automatic diffusion of the innovation (Wadsworth, 1990). Another important outcome of this approach is the definition categories of adopters (Rogers, 1962 mentioned by Rogers 1983) that were defined respect to the normal, "bell shaped" curve of frequencies of adopters throughout time. Innovator, Early adopters, Early majority, Late majority and Laggards were proposed. Other findings also include the influence of the perceived attributes of innovation; the communication channels in the adoption process and the characteristics of the opinion leaders and the individual within each category of adopters.

In respect to the characteristics of the innovators, Roger (1983) summarizes and classifies them into three main categories. Socio-economic characteristics, Personality variables, and Communication behaviour. For the first, the most important variables, that are positively related with innovativeness are: education, literacy, social status and size of the farm, For the second are: empathy, ability to deal with abstractions, rationality, intelligence and attitude towards change. For the third are: social participation, cosmopoliteness, contact with change agent, exposure to interpersonal communication channels and information seeking.

Finally, the diffusionist approach also supports that not only the characteristics of the adopter categories affect the adoption rates, but also the attributes of the innovation. The following attributes were identified: The *relative advantage*, which is the degree to which an innovation is perceived as better than the idea it supersedes. It is defined in terms economic factors i.e. price or profitability and social status such as prestige. *Compatibility* that is the degree to which an innovation is perceived as consistent with the existing values, past experiences and needs of the potential adopters. *Complexity* is the degree an innovation is perceived as relatively difficult to understand and use. *Trialability*, which is the degree to which the innovation may be experienced on a limited basis. *Observability* that is the degree to which the results of an innovation are visible to others. Finally, *the diffusion effect* that is the degree of

influence, upon individuals, to adopt or reject an innovation as it is gradually incorporated into the lifestream of the system.

More recently, more empirical evidence supporting these factors has been produced. However, some new ones have been identified and some new concepts and evidence have challenged the diffusionists approach.

Personal, familiar and farm characteristics

Working in the northern state of Nigeria, Voh (1982) investigated the relationship between some characteristics of the farm/farmer and the adoption level of a series of recommended practices. He found that the level of education, the level of literacy, the urban contact, the extension and advice contact, the socio-economic status, the leadership, the degree of empathy and the work off the farm were positively related with the rate of adoption. The household size, the age of the farmer and the extent to which the decision-taker contacts other people around him/her to make decisions, were not significant. In a more complex analysis he ranked the importance of the significant variables in the following order: leadership, the level of literacy, the extension contact, the empathy, the level of education, the urban contact, the additional education and the sociological status.

Similar results were reported by Mueller and Jansen (1988) in India showing that the age of the farmer, his/her school attendance and experience were significant factors affecting the adoption lag of a recommended pest control practice.

In Finland, Sipilainen (1994) studied the factors affecting the adoption of a subsurface drainage practice. He demonstrated that intention for introduction was affected by personal factors such as age and knowledge about features of the practice. Regarding to social aspects, this research showed that the introduction of this practice in the neighbourhood affected positively the intentions of farmers to adopt it.

Bryden (1994) in western Europe, demonstrated that farms with no change during a long period of time (10 years) were related to educational levels, number of economically active people in the family; the age of the farmer; labour input of the family members and off-farm work; the background of the farmer and spouse and the stage in the cycle of the farm family and the nature of the labour market.

In respect to personality, McGregor *et al* (1995) found in Scotland that innovative farmers had a more task oriented personality, they were more open to new ideas, more intelligent, lower in neuroticism, less stressed, more extroverted and risk minimisers

Extension strategy and managerial capacity

The work of Wadsworth (1990; 1995) on Costa Rican farmers showed that not only the farmer's characteristics have influence on the level of adoption of new practices but the intensity and strategy of the extension services. He found that the managerial capacity of the farm and the intensity of extension had an effects on the level of knowledge, evaluation and practice of new technologies. The interaction between these two factors also influenced the adoption rates.

Current technological level

The research of Frank (1995) in Australia demonstrated that the adoption behaviour of practices occurs in an ordered, sequential, step-wise process over time. The level of the actual practices in the farm will influence to what extent a new practice is likely to be relevant and adopted by farmer. This behaviour leads to an evolutionary process of change in which, at the beginning, adoption responds to basic and essential practices; more complicated practices will be introduced later.

Economic and market aspects

On the economical and financial aspects, it has been pointed out that the motivation for technology adoption is not only related to the decision-maker characteristics or his/her managerial skills to recognise advantage of the offered innovation, but there has to be an economic need for change (Frank, 1995). In the same way the economical and financial situation of the farm should have an effect on the adoption lag. In this respect, the study of Mueller and Jansen (1988) showed that variables representing production capital were non-significant in the adoption rate for pest control practices. However it could be argued that the extent by which economic variables affect adoption behaviour will depend on specific situations and the cost/benefit offered by the new technology.

The study of Sipilainen (1994) demonstrated that the decision-makers were more willing to accept a subsurface drainage practice when their farms were larger, due to better profitability and liquidity and entrepreneurial orientation and when expected returns seemed to be profitable. Frank (1995) in Australia reported similar effects of the perceived utility on the adoption behaviour. This author and others (Bryden, 1994) reported that an inadequate level of available resources is another reason for non-adoption of new practices.

Wadsworth (1995) showed economic constraints such as cash flow and the market conditions limited the adoption of even very basic and 'low cost' practices such as mineral supplementation in beef cattle farmers in Costa Rica.

Adoption lag, rates and categories of adopters

The low adoption rates that has been widely reported in several technologies in different parts of the world could be easily explained by the lack of understanding of the impact of the above explained factors that affect the evaluation or adoption process. Frank (1997) said that this multiplicity of factors challenge the relevance of adopter categories. The term 'laggards', in his point of view, is insulting and derogatory to people who have made an intelligent rational decision not to adopt. It could be added that farmers belonging to this category have had an evaluation process that takes more time, due to their specific situation, than other farmers in different status. In the same respect McClymont (1984) suggested that this process could take from little as a few months to several years depending on personal, financial and situational aspects. These results represent, according to this author, serious questions to the classical studies of adoption rates and the concept of innovativeness since two farmers could be equally innovators but the individual situation could retard the adoption in one of then. Wadsworth (1995) provided a step forward in recognising that farmers characteristics are just one part of the equation explaining the adoption rates but the extension strategies and their intensity have an important role.

2.2.4 Evaluation of solutions and new practices

Forecasting of outputs

In this step, also called Analysis (Öhlmér *et al*, 1998), each alternative of solution or a new technology are evaluated against goals through a predictive judgement (Öhlmér, 1992). There are several factors that are taken into account in this forecasting process. It has been pointed out that the decision-taker proceeds to a reasoned experimental phase in which simulated exercises on paper, mind or discussions with neighbours, watching their neighbours or small scale trials take place (McClymont, 1984). In the process of evaluation, information (internal an external) is used to help in predicting the outcomes of the alternatives (Errington, 1986).

2.2.5 Decision-making

According to Öhlmér (1992) in the decision-making phase, the decision-taker chooses (but does not necessarily implement it) the action, with the highest utility or, alternatively, the action that satisfies the aspiration levels. In other words the alternative that, after the evaluation process, predicted outcomes that fulfil his/her economical, personal or social goals.

2.2.6 Implementation

This step involves acquiring the necessary resources, and putting the plan in action (Öhlmér *et al* (1998). According to Errington (1986), the farm's permanent labour resource includes the farmer's own work, his/her family and the employees. The manner in which the work is divided among them will have a significant impact on the achievement of the objectives. From this point of view, the study of the delegation of work and decision-making seems to be crucial in order to increase the understanding of the decision-making process.

Delegation of actions and decisions

The delegation of actions is a process by which decisions are implemented. This process occurs when the decision-taker induces someone else of his/her workforce to do so (Errington, 1986). In the same manner, some decisions and their implementation could be allocated to other members of the staff (Errington, 1986).

A Study in Zimbabwe (McClymont, 1984) demonstrated that delegation of decisions is likely to be found in week by week planning decision regarding operational activities of the farm.

The delegation of decision-making seems to be related to the type and characteristics of the decision e.g. hierarchy (managerial to non-managerial); strategic and tactic; the level of reversibility; the frequency of the decision and the information requirement. The study of Errington (1986) showed that "strategic decisions" are less likely to be delegated than "tactical decisions" due to their impact on the objective achievement and the period of time when their effects are felt. He also found that decisions with low reversibility are less likely to be delegated while those frequent decisions were easily delegated. He argued that experience is rapidly established in frequent decisions and therefore the subordinate is able to decide in different circumstances using their decision rules. Finally, decisions that require a high proportion of information that cannot be easily measured and recorded are delegated to the people that can gather this information in a mental way.

Looking for relationships between farm and farmers characteristics and the level of decentralisation, as measurement of the level of delegation, Errington (1986) demonstrated that farm characteristics i.e. number of cows, size of the workforce, physical size of the business, have a positive relation with decentralisation. Farmer's characteristic such as the proportion of time spend on the farm had the expected negative relation. The attitude towards delegation showed to have a weak impact, while farmer's age had an unexpected positive relation showing that older farmers tended to delegate more. This is explained by the author as an response reduction of stress of decision-making and because the his/her disadvantage respect to information in respect to farm staff.

2.2.7 Monitoring and feedback

This step includes activities such as searching and storing of information coming, through the feedback, from outcomes of prior decisions (Sarary, 1993; Öhlmér, 1992; Öhlmér *et al*, 1994). This information could be stored in memory (Öhlmér, 1992) as experience (Savary, 1993) and used for future decisions (Timko and Loyns, 1989) in posterior steps of decision-making such as assessment and problem detection. Other types of information that are subject to be monitored could be those coming from personal networks, books, media, farmers magazines, and advisors providing measurable indicators (Öhlmér *et al,* 1994). According to Savary (1993) farmers accumulated this information and lead to a transformation process by which a group of management options, standards and references are created.

In summary, monitoring is the step of decision-making in which all the information coming from external and internal sources is searched and stored in order to support the whole decision process.

2.3 The decision-making units

Throughout this review on the decision-making phases, the process seems to be executed by only one person using information from different sources. However, there is controversy around who is (are) the person/people who actually make the decisions in the farm. From this point of view, it is worthwhile trying to answer this question based on the empirical evidence available.

In this respect, it could be said that there are four lines of thought that have started answering this question. The first one, supported by economists and psychologists and by more empirical evidence, demonstrates the monopolisation or unity of authority in farming decision-making. This authority rests, almost as a role, on the male farmer in terms of decisions related to farming activities such as labour allocation and production (Vail, 1982). This male preponderance is only broken in very special or rare circumstances when divorced, widowed or a single woman takes the role of decision-taker as individual (Berlan, 1988). Whichever the case, unity of authority is still existing despite the gender. Some empirical evidence demonstrates the limited power of women in the process. The research of Bokemeier and

Garkovich (1987) and Vail (1982) in the United States showed that women participate in no more than 5% of the farming decisions. However, the level of involvement of women in farming decision is affected by social values in different countries. For example, Sisodia in India demonstrated that women participate in more than 30% of decisions related to crop selection and management.

The second line of thinking is still in favour of the unity of authority but acknowledges the influence of other people, often the spouse, as opinion sources. These people have been called as "Significant Others" or "Trusted People" (Errington, 1986). There is evidence showing that the relative importance of this opinion sources increases in strategic, large financial or risky operations (Sutherland *et al*, 1996) and in long term decisions (Henderson and Gomes, 1982; McClymont 1984). Ferreira (1997) demonstrated that the farmers made between 48% to 81% of the decisions regarding to management, pasture, animal buying and sales, showing that the level of involvement of the family and other trusted people was also important for the three decision-making unit profiles he found.

The third point of view puts the family as the real decision-making unit, where the family members are not only opinion sources but they are actually actors making egalitarian or joint decisions (Jones, 1967; Dent, 1995) through a negotiation process (Errington and Gasson, 1994). Family members act more frequently in decision regarding investments (Berlan, 1988) and capital (46%) and less frequently in labour allocation (32%) and general production (18%) (Vail, 1982).

Interactions between psychological, micro-social (household) and macro-social (social environment) factors e.g. individual self-identities, personal resources, family dynamic, structure of the farm enterprise and structure of the labour market are factors affecting the level of involvement of the spouse in the decision-making process (Bokemeier and Garkovich, 1987; Berlan, 1988). The desire of unity and authority on behalf of family male is also preponderant (Sutherland *et al,* 1996).

As discussed in the previous section, although supported by little evidence, the fourth line of thinking goes further in recognising that other people, outside of the family, are allowed to make decisions. The evidence presented by Errington (1986) and McClymont, (1984) suggests that the importance of this other decision-units depend on the type of decisions and some farmer/farm characteristics.

In conclusion, it could be said that the extent to which other people participate in the decision-making process depends on very specific circumstances, type of decisions and farm/farmer/family characteristics. Under this point of view it could be said that these varied lines of evidence could either co-exist or become preponderant as a result of the very specific conditions of each study. It is to say that the decision-making unit is not only one but several and that they co-exist in the same farm at the same time. What is clear is that more evidence, especially from developing countries, is necessary to understand this phenomenon and by this way go towards a better understanding of the decision-making process.

2.4 Information

Information is an input used in all the steps of the decision-making process (Timko and Loyns, 1989; Öhlmér, 1992), especially in the problem detection, seeking for solutions (including new practices) and evaluation phases. Therefore, is it necessary to study this input in greater detail. Issues like origins, sources and media of information and the preferences of the farmers are very important to understand that whole process of decision-making.

Information becomes available to the decision-maker through different media, origins and sources. According to Errington (1986), information sources could be classified according to their origin: internal and external; according to their media: direct observation, verbal or written and according to their sources: recorded numerical data, comments from people and the decision-maker's own past experience. "Trusted People" , "Significant Others", and "Information digestors' (Gasson, 1973; Errington, 1986; Ferreira 1997) are concepts used to describe groups of people who are close to the farmers and are sources of opinion, information and knowledge and have an active role in the decision-making process. People belonging to these groups could be members of the decision-maker's family, Other farmers, members of the farm workforce or professional advisers etc. (Gasson, 1971).

Rather than specific people as informational sources, some authors have defined different information systems which are used by the decision-making units. Chambers (1983) defined the concept of Rural People's Knowledge [RPK] as:

> *The knowledge of people and existing system of concepts, beliefs and ways of learning. Include both small and large farmers. The knowledge is located in people and rarely written down. Knowledge refers to the whole systems including concepts, beliefs and perceptions, the stock of knowledge, and process whereby is acquired, augmented, stored and transmitted.*

Rölling and Engel (1991) developed the concept of Agricultural Knowledge Information Systems [AKIS] as follows:

> *The set of organisations and/or persons, and the links and interactions between them that are engaged in, or manage such processes as the anticipation, generation, transformation, transmission, storage, retrieval, integration, diffusion and utilisation of agricultural knowledge and information, which potentially work synergically to support decision making, problem solving, and innovation in agriculture or a domain thereof (page 125).*

Some examples of empirical findings regarding to the role and importance of different media and sources of information are available in the literature. In a big sample on four states of the United States, Ford and Babb (1986) demonstrated that farmers prefer the personal and service-oriented media rather than written information. In Scotland Sutherland *et al* (1996) provides evidence of why farmers prefer this media. They found that, from the point of view of the farmer, information in press is often late in relation to other sources of information and of little use because it is written in general terms and is perceived as inaccurate. In terms of personal media, there are some contrasting findings showing the relative importance of different personal information sources used by farmers in decision-making. They also found that other farmers and agricultural advisors and consultants were the most important information sources for assistance and reference figures. Important

findings of this research were that self-reporting performance from other farmers was distrusted; while monitoring them was perceived as of great interest. On the other hand, they trust non-family agents (advisors) because of their objectiveness and independence. Ford and Babb (1986) found that in terms of crop decisions (with few differences with livestock) family and friends were the most important information sources. However other farmers, private firms and extension services were also used for these purposes. Blum (1989) in Israel, found that for awareness of innovation and implementation, the importance of family and extension advisors were very important. Nevertheless, for the former step, the two information sources were equally important whilst for the latter the extension adviser became more influential.

In terms of sources of opinion, the evidence shows that the family is of primary importance in planning decisions and in large financial and strategic decisions (Henderson and Gomes, 1982; Sutherland *et al*, 1996). Sutherland *et al* (1996) also documents the important role of the extension worker, as opinion source in planning and decision-making.

In summary, it could be said that the personal sources of information are the more preferred by farmers. On the other hand, family members and extensionists/advisors are the most used information sources and therefore they conform the basis of Trusted People group. In spite of the evidence available, some questions remain and need to be answered in order to understand the decision-making process: 1-What is the relative importance of different Trusted People in different phases of the decision-making process?; 2-Which are the farmers'/farms' factors affecting the preponderance of some personal information sources over the other?; 3-How does a farmers' population is naturally divided and how can they be classified?

2.5 Objectives as the motivation component

Under the assumption that decisions are made in order to accomplish some desired status, objectives or goals become the motivating components of the decision-making process. Therefore it is worth to define which is (are) the goals driven the decision-making process in agriculture.

In this respect it should be said that objectives in agriculture have been conceptualised in an oversimplified way, which is product of the orthodox economic

theory. From this point of view, the farmer is considered as a person acting almost exclusively towards maximisation of the biological (e.g. products, foods) and financial outcomes (e.g. cash, capital) of the farm (Gasson, 1973; Dent, 1995; Ferreira, 1997; Frank, 1997). Recent examples in terms of simulation and multiple criteria decision models (Herrero, 1997; Herrero *et al*, 1999) have made considerable progress in including several goals into the models. However even in these cases, goals have been represented by easily measurable economic objectives such as revenue, cash flow, capital etc. Non-economic objectives have not been taken into account probably due to: the lack of understanding of their relative importance, difficulty of measurement and representing them in the models.

From the available empirical evidence, it could be said that the two types of goals (economic and non-economic) are not mutually exclusive but they coexist in the farmer's mind. However there is not enough evidence that proves a preponderance of one over the other. Some research shows that monetary economic goals are preponderant than non-economic, being the former instruments towards the latter (Henderson and Gomes, 1982). Other evidence shows the opposite relation (McGregor *et al*, 1995; Frank, 1997). Equality between them has been also found (Perkin and Rehman, 1994). Finally other studies show that the preponderance depends on time term of the decisions involved (McClymont, 1984; Jacobsen, 1994). These contrasting results could be products of real differences between the studied populations or differences in the methodologies and techniques used to ask the farmers to express their attitudes towards different goals.

Some advances have taken place studying the factors affecting the objective priorities. In this respect, Perking and Rehman (1994) in England, showed that age and education were correlated with life style objectives where old people are more likely to remain in the farm and less likely to want time for other activities. In high educated people, an inverse behaviour was found. This study also showed that the economic assets of the farms also affected the hierarchy of objectives. The work of Austin *et al* (1996) in Scotland, showed that the age of the farmers was positively correlated with the Yeoman management style (goals orientated towards family farm continuity and risk aversion financial practices), while negatively correlated with the Entrepreneurial style (goals oriented towards optimisation of financial return and

personal achievements), showing that young farmer are more success-business oriented than older farmers.

All these findings suggest that the hierarchies of objectives depend on particular situations defined by the level of planning, the type of decision, personal characteristics of the decision-maker and type of production system, etc. This multifactoriality makes it impossible and pointless to attempt to obtain a unique pattern that defines the hierarchy of goals within a population or to obtain a consensus among studies under different conditions. From this point of view it is necessary to look for patterns of objectives within a population, and classified the farmers into well-defined groups. Some attempts in defining patterns (some times called Management styles) are available in the literature, many of them obtained using multivariate techniques. Labels like 'Dedicated producer', 'Flexible strategist' and 'Environmentalist' (Fairweather and Keating, 1994); 'Yeoman' and 'Entrepreneurial (Austin *et al*, 1996) 'Innovative sustainable', 'Entrepreneurial imitators' and 'Traditional routine' (Ferreira, 1997) have been proposed.

From this evidence, it could be said that it is necessary to obtain more empirical proofs of hierarchies of goals, the factors affecting them and the population patterns. This is more desirable from developing countries from where little evidence is available. More methodological approaches are required to improve the state of the art in term of understanding objectives and the decision-making process as a whole.

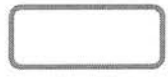
2.6 An expanded conceptual model of the decision making process

Having defined, from literature, the decision-making phases, the decision-making units, information flows and their goals, it is now possible to construct an expanded conceptual model of the decision making process. This model includes, as building blocks most of the above explained aspects as well as the experience of the author as a technical advisor to dairy farmers in Costa Rica. The objective of this model is to provide a broader point of view of the process in order visualise its complexity and discuss some additional considerations. This conceptual model is an attempt to represent the decision-making process that occurs in the most complicated situation. This situation assumes that the process is catalysed by a cognitive dissonance after a rational and purposeful assessment of the actual parameters of the farm against the

objectives that leads to a proactive searching and evaluating of solution/technologies. On the other hand, a decision-making process in farms where, due to its size or complexity, delegation of decision-making and functions occur. Once the model is developed, important issues to be addressed are identified from which hypotheses of this thesis are defined.

The expanded conceptual model is showed in the Figure 2.1. The symbols are explained in Table 2.1. All the components and flows are identified with a code that could help the reader to follow the explanation. In appendix 1, the whole codebook of the model is shown and all the components and flows are explained in detail.

Table 2.1. Symbols used in the conceptual models of the decision-making process

Symbol	meaning
	**Information pools**
	**Actions/activities**
	**Decisions**
	**Subsystems/people**
	**Databases**
	Flow of information
	Actions performed by people
	**Action flow**

Decision making is a cyclic process without a beginning or an ending step. It is constituted by a series of activities or recurring processes whose outputs are the inputs of others, some of them occurring simultaneously.

The process takes place in the domain of three different systems i.e. socio-economic (sece), the farm household (dmu) and the production system (farm). Each

system provides information and different activities that compose the expanded decision-making process. In this conceptual model, the farm household is the decision-making unit, where different members (dmufm) of the family have participation in terms of definition of objectives (dmuneg) and opinion exchange for decision-making. Although this model recognises that different members of the family share some types of decisions, the farmer represents the final decision-taker (dmup). He/she makes decisions, mostly related to the farm management, as an individual, taking into account the opinion of other members and the family's objectives.

Within each system, information is monitored and processed in order to obtain meaningful parameters that are necessary to maintain the whole process. In terms of the socio-economic environment, information such social standards and values; opinion; knowledge and the surrounding situation (secim) are monitored (seceim) from trusted people/key informants (secetp) and information media (seceifm) from the social and economic systems. This information leads to the definition of a set of reference parameters (secerp) including acceptable standard of living, acceptable technical parameters and management practices, social and family costumes etc. On the other hand, in the production systems, information such as the performance of different subsystems of the farm (farmss) (e.g. pastures, animals, herd etc.) is monitored (farmin). By means of some instruments (farmmi) including management information systems; manual records or mental perception, this information is stored and then processed in order to obtain technical and economic/financial parameters (farmtp) of the system. Finally, within the farm household, information such as education achievements, health condition, good satisfaction and security is monitored (dmump) from each member of the family leading to the awareness of the actual socio-economic and health parameters (dmusep) of the farm household.

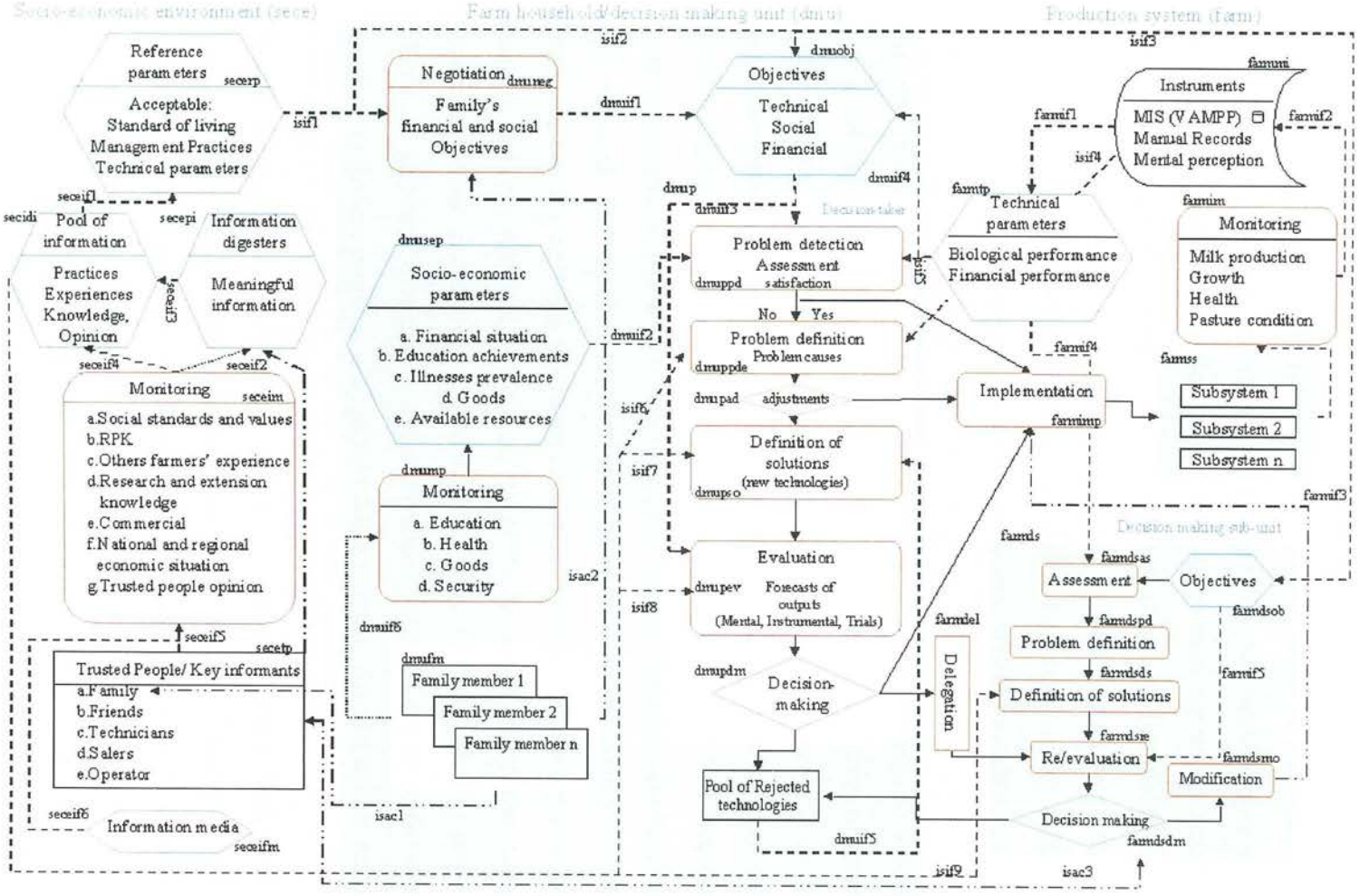


Figure 2.1. Conceptual model of the decision-making process

The definition of values and objectives could be conceptualised as a basic process that takes place within the farm family as a product of negotiation where all the objectives of each member are considered in order to define more general social and financial goals of the family. The personal goals are products of the continuing monitoring of socio-economic reference parameters, which at the same time are reference parameter during the negotiation process. The familiar financial and social goals are then translate into technical, financial and social objectives (dmuobj) for the production systems in order to ensure their satisfaction. The objectives are then transmitted to other people in the production systems such as the operators, manager etc. thereby they become award of technical goals to be achieved. The objectives are normally expressed in terms of performance figures and permissible management practices that are meaningful in terms of management. They are often kept in mind and in few cases written down on paper. Finally, It could be argued that similar processes of objective definition are likely to be found in the case of farm staff (farmds) whose goals will have an effect on the whole decision process of the farm.

Once the values and objectives have been defined, the decision-making unit will detect problems when those desired goals are not being achieved. This step could be defined as the problem detection step (dmuppd). Since parameters are continuously being obtained by monitoring, problem detection is a continuous process encouraging the farmer to engage in decision process every day. In a proactive way, the farmer makes a purposeful searching for problems by an assessment comparing the socio-economic and technical parameters against the goals. In a passive way, problems are detected when they become obvious affecting the goal achievement. In both ways, problems produce a cognitive dissonance or dissatisfaction status that push the farmer to take decisions to eliminate this mental status.

When a problem has been detected, the farmer starts a process of definition of the dimension of the problem and to identify possible causes by means of a detailed review of the management process (dmuppde). This process includes activities such as analyses of the production records, tests and laboratory analyses, review of the management of different subsystems etc. On the other hand implies an active reaching for opinion from the pool of information (secidi) coming information

digesters (secepi). When the origin of the problem is related to distortions in the implementation of the prior decisions that are part of the current management system (dmupad), adjustments are made in order to correct these biases. Otherwise the farmer needs to be involved in subsequent steps of the process.

When the problem definition fails in solving the problem but was successful in identifying the causes, farmer is involved in an active searching for alternative solutions (dmupso). It could be hypothesised that there is a hierarchy of levels in which the farmer searches. Firstly his/her own experience from which he/she recalls old practices that have had success in the past in solving similar sort of problems or those that have fulfilled his/her expectations. In this terms re-adoption of dis-adopted practices or technologies could be considered by the decision-taker. The second source could be "Trusted People" immediately near to him such as family members and farm staff. Then the opinion/experience of other farmers, extension agents and advisors ("Information Digesters") and media through which the farmer find alternative solutions belonging to the Rural People Knowledge, Indigenous knowledge and Scientific knowledge or a mixture of them. Throughout this process the farmer made a pre-selection of alternatives that are likely to solve the problem.

The awareness of new practices is not necessarily a proactive process of searching for solution when the farmer is facing a problem. It may occur when the farmer becomes aware, in a passive way, of a new technology or practice. This new technology could have been developed to solve problems that the farmer is not facing, or believe he/she is not facing at the moment. This awareness leads to the recognition of the problem and hence a cognitive dissonance or the identification of an opportunity of improvement that lead to the consideration of the new practice.

Once the farmer has a reasonable amount of alternative solutions, he/she begins an evaluation (dmupev) process in which predictions of the outcomes of the eventual implementation these alternatives are estimated in order to evaluate its potentiality against the objectives. On the other hand, the adaptability of the new practice and costs are also evaluated. The forecast is made by means of mental models or using instruments such calculators and computerised models etc. Trials and temporal adoption of the practice are other ways by which a technology is proved under the farm reality in order to obtain a more realistic prediction of its goodness. This

process of evaluation implies the modification and/or blending of several practices in order to evaluate a group of alternatives that have the best-expected outcomes. Opinion of "Trusted People" is also valuable for him throughout this step.

Decision-making (farmdm) occurs when a practice/solution, or a combination of them, shows to have the best predictions in terms of achievement of the objectives of the farm family and proved to be compatible/adaptable.

Implementation (farmimp) takes place when the new practice or solution is put in to action as part of the current management system. This implementation could be made directly by the farmer or, in some cases, through the delegation of actions (farmdel), by other people. When delegation is made, a re-evaluation of the practice could be made by the operator through the assessment of its applicability in term of its own objectives, experience etc. This delegation may lead to an authorised or authorised decision-making (farmds) by which the new practice or solution in adopted with modifications (when necessary) or rejected.

The authorised delegation of decision-making could be seen as the creation of decision-making sub-units. This delegation is mostly related to management decisions of subsystems where the farm-staff possess a better level of information than the farmer/farm family. This process is driven by the farmer/farm household objectives as well by the operator's own goals.

Through the feedback, information regarding to the implementation of the new practice or solution is monitored in order to evaluate the actual outcomes of the decision. When the decision has satisfactory outcomes and the technical parameter are improved; re-definition of objectives, mostly those technical are likely to be made.

2.7 The impact of the decision-making aspects and the managerial capacity of the farmer on management and performance

From literature review and the conceptual model of decision-making, one important question arises: what is the relationship between the decision-making aspects and the farmer's characteristics with the management practices and performance of the farm?

In this respect, it should be said that there are few cases in the literature that addressed this relationship. The majority of reviewed studies are limited to the relationship between the farmers' personal characteristics and management and performance without including variables more related to the decision-making aspects. Some of them have only related some management practices and the productive performance of the farms. Others have evaluated the impact of some farmers' characteristics with the use of technologies and recommended practices. Others have linked the farmer, management and performance. The managerial capacity of the farmer has been represented by several characteristics including educational level (the most common), objective orientation, access to extension services and hired technical advising, literacy, numerity, abstract, reasoning, parameters of the farm, or a combination of them.

The studies of Goodger, *et al* (1988) and Kierna and Heinrichs (1994) in the United States are examples of studies characterising management practices and evaluating their relation with performance. They found positive effects on performance in those farmers who adopted some recommended practices. The work of Solano *et al* (2000) in Bolivia, found close relationships between the use of different technologies in pasture and nutritional management with several farmers'/farms' characteristics such as educational level; level of openness towards informational sources; use of technical advice, farm remoteness and size. Achten *et al* (1983) evaluated a more comprehensive characterisation of the farmers including education, skillness, decision making aspects and objectives and found and slight relation with yield level in greenhouse producers in Netherlands. The work of Costa and Rehman (1999) in Brazil is a successful attempt to characterise, in a better way, the farmer's goal orientations and relate them with management. They found that driving goals altered their desire of having as many animals as possible with the subsequent impact in pasture degradation. However no other farmer's variables were taken into account in this study. The work of Rosemberg and Cowen also in the United States found positive relations between the attitudes of manager towards the workers with the use of records keeping on the productivity of the dairy farms.

The economists have made an important contribution in studying the impact of the managerial capacity on efficiency (technical, allocative, economic). Most of them

have used Stochastic Frontier and Non-frontier models to measure the influence of age, educational level, experience and contact with extension services. The majority of them have included these variables within the models to shift to the frontier without modifying the elasticities of the inputs. Nevertheless, in all these studies, the representation of the farmer has been very narrow, mostly referring to biographical variables.

The study of Stefanou and Saxena (1988) in United States demonstrated that the educational level and the experience of the farmers were substitutes and that they had a positive impact of the efficiency measured as input allocation. Wang *et al* (1996) found in China that household educational level, per capita net income and the family size had positive influence on the profit efficiency. Adesina and Djato (1996) found in rice farms in Ivory Cost the same result with respect to the educational level and extension contact. The work reported by Jamison and Moock, (1984) in Nepal, using a non-frontier technique (average production function using least square means estimates) shows the same effect for education and extension contact and some effect of numeracy on crop productivity. Using the same technique, Moock (1981) found the same positive effect of education and extension. An interesting finding of this research was that these two variables were substitutes and the effect of the extension was higher in low educated farmers than in high educated ones. Finally, Wilson and Hadly (1998) found in the United Kingdom, relationships between experience (negative), farm size, irrigation etc, with the efficiency. They found a very small variation in the efficiency in the population very close to the efficiency frontier.

All these studies are attempts to explain the observed difference in productivity and efficiency in agriculture that have traditionally been regarded as effects of management without any definition of its real nature and quantified the actual impact of the managerial capacity of the farmer. From the brief literature review, it is clear that economists have made a good progress in the development of algorithms to measure efficiency. However, the representation of the human component within the model has been very limited and narrow.

2.8 Hypotheses of the research

Having shown a literature review of the components and the dynamic of decision-making process and having developed an expanded conceptual model of the process, it is possible to identify those aspects of interest for the purpose of the present work. Taking into account the complexity of the process and the scarce empirical evidence, at least from developing countries, three aspects were selected to be studied in detail in this thesis, from which the following null hypotheses were defined.

2.8.1 The objectives in Costa Rican farmers

"*As normally assumed, the objectives of Costa Rican farmer are oriented to the maximisation of biological outcomes or profit of the farm, while other personal and familiar objectives are less important or not significant. These objectives are unaffected by farmers/farms characteristics*"

2.8.2 Who makes farming decisions?

"*Farming decisions are made by a single decision-maker, who takes into account the opinion of other members of the family and trusted people. This monopolisation is constant under different types of decisions and farmers'/farms' characteristics. Under this monopolisation no decision-making sub-units exist in the farm.*"

2.8.3 Personal Informational sources

"*The personal information sources, as the major significant sources used by farmers to make decisions, are the same regardless of the step of the decision-making in which he/she is. The majority of information for farming decision comes from the formal sector through the extension services and technical advisors and that it is independent of the farmers'/farms' characteristics* "

2.8.4 Relationships between decision-making aspects and management practices

"*The management practices of the farm are not related to objective orientation, the decision-making approach or the personal informational source used by the decision-making unit*"

2.8.5 Relationships between decision-making aspects and farm performance

"*The performance of the farm is not related (directly or indirectly) to objective orientation, the decision-making approach or the personal informational source used by the decision-making unit*"

2.9 General considerations

The literature review and the expanded conceptual model demonstrated the complexity of the process and the lack of empirical evidence on the majority of the components, flows of information and actors involved. Although objectives, decision-making units, information sources and adoption process are the most studied components, little evidence comes from developing countries. It means that, before engaging in more in-depth research on the whole process, these key elements of the system should be better understood under wider variety conditions where social and personal factors could shift the whole process significantly. The general objective of this thesis to present some empirical evidence from diary farmers in Costa Rica, that could lead to test the above explained hypotheses.

Chapter 3 Dairy sector, sampling and farms/farmers description

3.1 Introduction

The aim of this chapter is to provide some relevant information that could be required by the reader to understand the results of this work in the context within which both the farms and farmers exist. Firstly, general information of Costa Rica as a country is provided. Secondly, information about the performance and relative importance of the dairy sector in the economy of the country is discussed. Thirdly, the universe of search is defined as well as the criteria used to select the sample. Fourthly, the interview and the program used to store the information are briefly described. Finally, using univariate analyses and frequency tables, a general characterisation of the farms and farmers in the sample is made. Most of the parameters used in this section are the result of the analyses executed throughout the thesis, therefore details on their calculation are not explained here but in their respective chapters (mostly in chapter 6).

3.2 Costa Rica

Costa Rica is an independent, democratic country with a republican government system. It is located in Central America (lat 9-11° N) and has a population of approximately 3.5 million people (World Bank, 1997). The country has had not army since 1951 and is constitutionally neutral since 1982. It is surrounded by Nicaragua at the north, Panama at the south, the Pacific ocean at the east and the Caribbean sea at the west (Figure 3.1). Its area is around 50,700 km2 from which 10% is used in crops activities, 46% in pastures, 30% in forest within protected areas and the rest in private forests (World Bank, 1997; FAOSTAT).

Figure 3.1. Map of Costa Rica

3.3 The dairy sector in Costa Rica

As can be seem in Figure 3.2, the milk production has considerably increased from 429 to 550 millions litres/year from 1990 to 1997. As a consequence of this increment, the country is self-sufficient and able export the surplus (Figure 3.3).

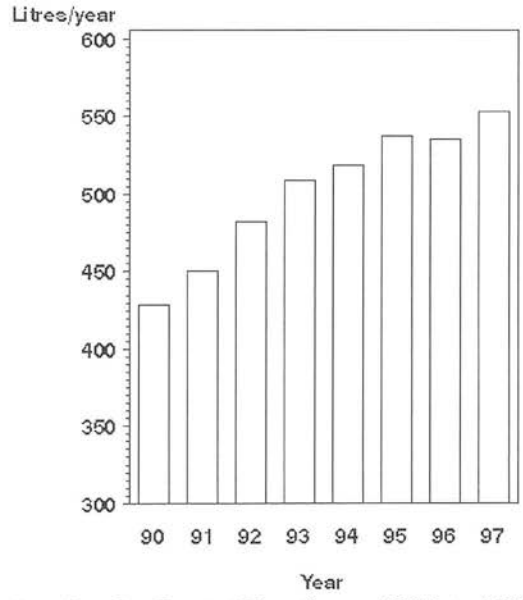


Figure 3.2. Milk production in Costa Rica from 1990 to 1997 (millons of litres) (source Infoagro/SEPSA/BCCR, web site www.infoagro.go.cr)

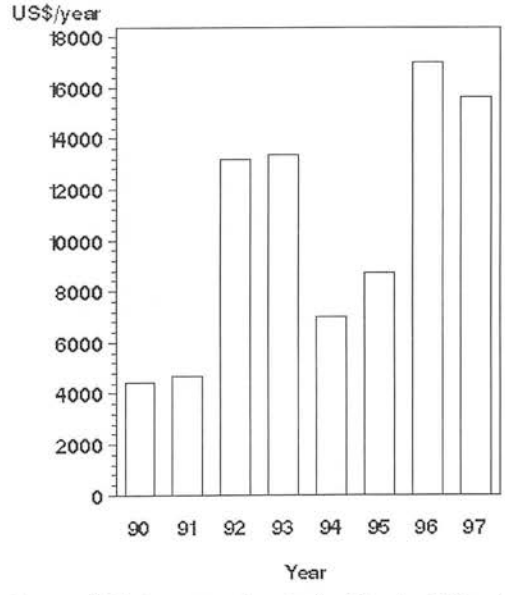


Figure 3.3. Exportations of dairy products in Costa Rica from 1990 to 1997 (thousands on dollars)

In 1999, the agricultural sector represented 17% of the GDP (Gross Domestic Product) of the country. Milk production represented around 12% of the agricultural GDP and around 3% of the total GDP. The pattern in Figure 3.4 shows that the importance of the sector has increased in the last 9 years (Infoagro/SEPSA/BCCR). Around 50% of the milk produced in the country is pasteurised and processed into dairy products (Pomareda, 1994). There are around 34,469 farms (dairy and dual purpose) in the country (Camara Nacional de Productores de Leche de Costa Rica, 1998). Although the importation tariff has been very high in the last years (more than 110%), the compromises of the country in the GATT is to reduce the tariff upto 60% by June 2001 (Camara Nacional de Productores de leche).

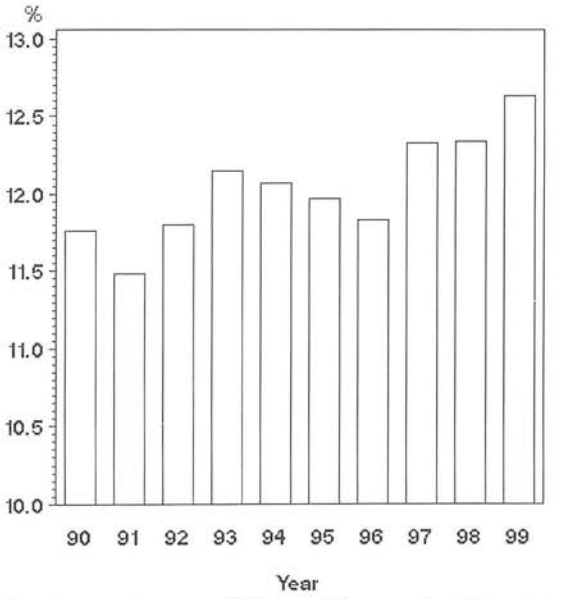


Figure 3.4. Relative importance of the milk production on agricultural GDP

Current prices in the market (Dos Pinos co-operative) are:

kg of milk solids=$2.178 +

kg of milk fat =$0.331 +

2% milk quality (-100,000 bacteria)

3.3.1 The sampling

The research population was 2081 dairy and dual-purpose farms that sell milk to dairy factories and farmers' co-operatives. This population represents around 6% of the total dairy farms population in Costa Rica (34,469 farms) and represents around 50% of the total milk production in the country. This research universe was selected because they are the only farmers whose information about their location and production levels was known. Unfortunately, the lack of a recent national survey made it impossible to take into account the whole population.

Once the universe was identified, farmers were separated according to two criteria. The first one was a geographical subdivision of the country. Four well differentiated regions were defined according to the geographical and environmental conditions. The North region (North) is a humid, low land environment, with rains throughout the year. This is the biggest dairy region in the country. The Pacific region (Pac), which represent farms in low lands, with around 6 months of dry season and mostly dual purpose production systems. Central Occidental region (Cocc) and Central Oriental region (Cori) which are high lands, mostly specialised dairy systems. The second level was defined according to the level of milk sales per week (strata). Three strata were defined using 33 percentiles in order to obtain small, medium and large farms (at least from the point of view of the milk sales).

Farmers were selected within each region-strata using a systematic method. The first farm was selected randomly and the following farmers systematically selected each n farmers (n= total number of farmers in each region-strata divided by the number of samples required within each region-strata).

The sample size was calculated to derive a population mean of milk sales per week with 10% of error. Although a minimum of 80 farms was calculated to be enough to accomplish this accuracy, one hundred interviews were made from which 9 were discarded for problems of completeness, inaccuracy and one because the farmer was not able to read or write. Figure 3.5 shows the distribution of samples throughout the country.

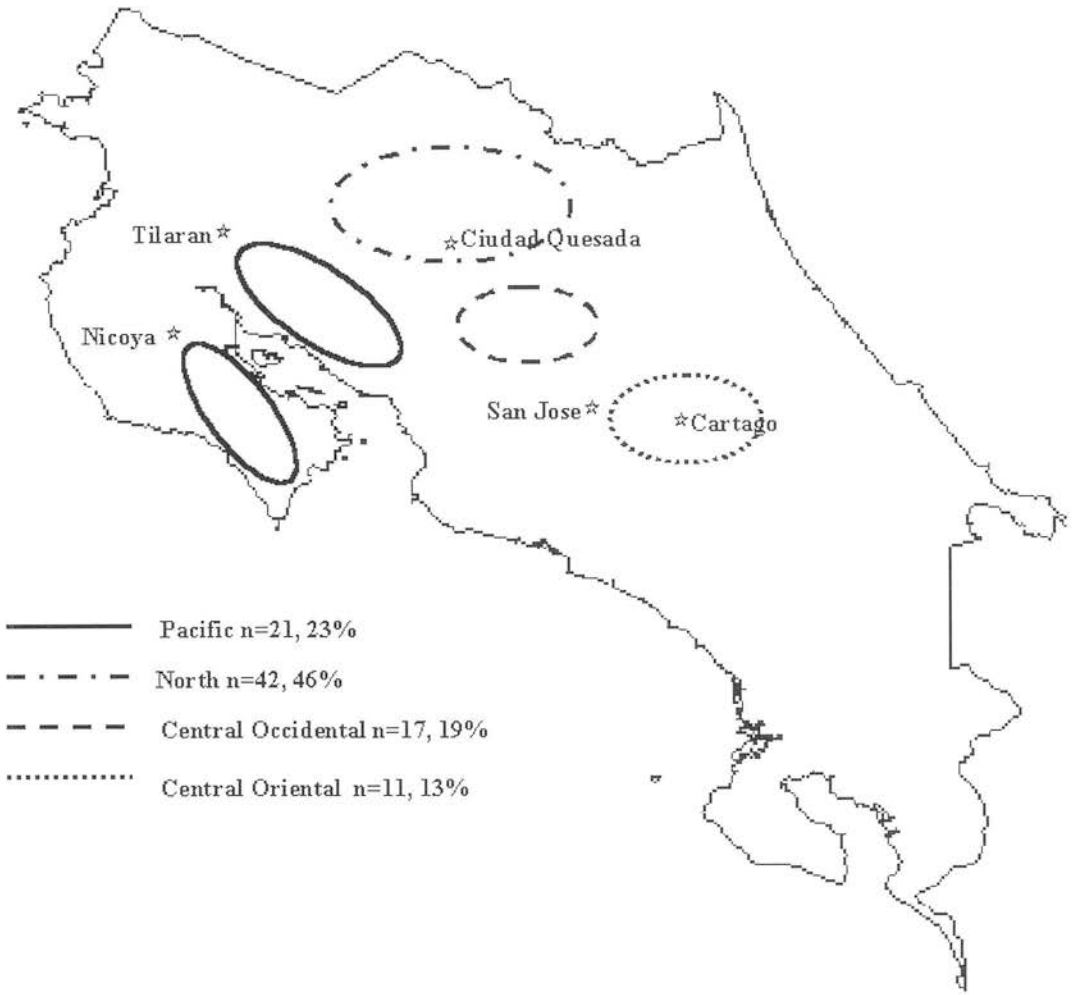


Figure 3.5. **Sampling distribution throughout the country.**

3.3.2 Interviews

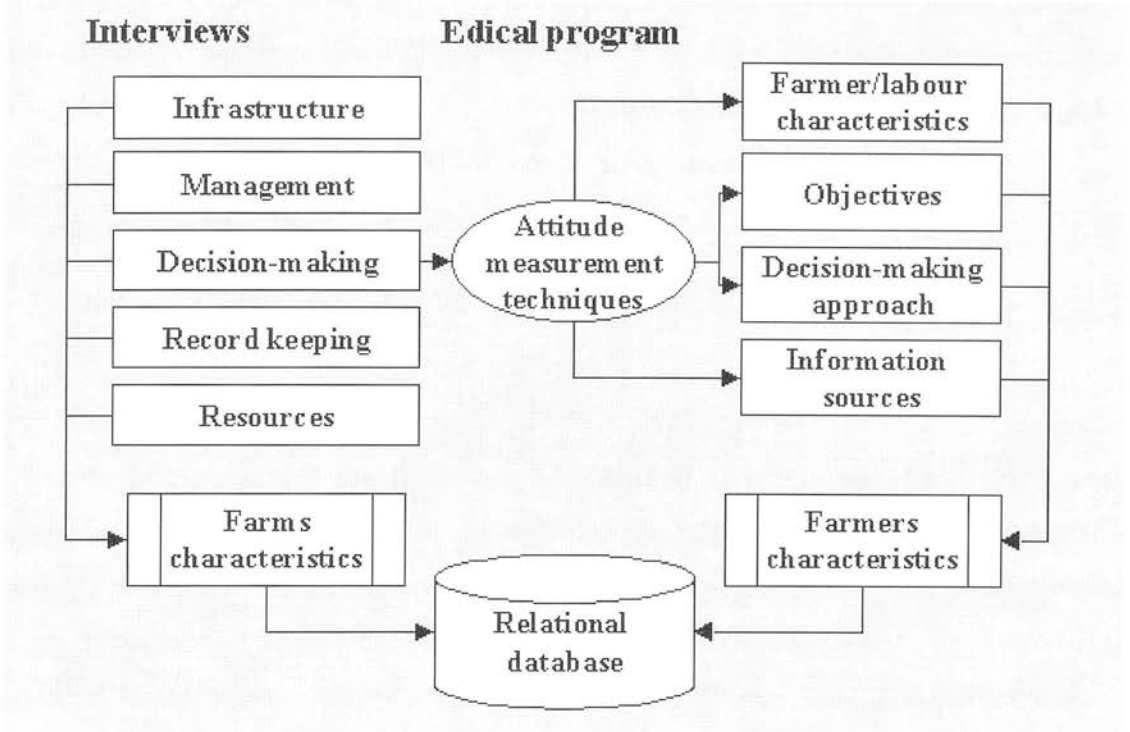


Figure 3.6. Structure of the of the interviews in the Edical program

The interviews were made based on farm visits and recorded into Edical (Dynamic Survey for dairy farms characterisation) which is a computerised questionnaire using a relational database and written in Delphi object-oriented language. This program was designed and written by the author in order to increase the quality of the data, reduce sampling errors, and reduce the time involved in both, the questionnaire itself and data typing. It was accomplished by introducing several data quality controls and data interchange among different parts of the questionnaire.

The interview recorded information about i.e. resources availability, infrastructure, management, and some decision-making aspects including record keeping systems, farmer and labour characteristics, farmer's objectives, decision-making approaches, informational sources. The last three aspects were recorded using some attitude measurement techniques (explained in detail in chapters 4, 5 and 6). The structure of the

interview is shown in Figure 3.6. Two interviewers performed the interviews. The author was in charge of the interviews in Central and Pacific regions, while another person was in charge of the interviews in the North region. This person was previously trained in Edical and the questionnaire by the author. Two pilot surveys (not taken into account in the analyses) were made before the data collection in order to test the survey and for training purposes. Not test for interviewers' bias was done.

3.4 Description of the farms and farmers

3.4.1 Farms characteristics

Eighty five percent of the farms can be classified as specialised diary farms, with specialised breed where the calves are separated from the dam some hours after the birth and the production orientation is almost exclusively towards milk. The remaining 15% were dual-purpose farms where breeds are mostly crosses between Bos taurus and Bos indicus. In these farms calves are allowed to suck milk and production orientation is towards both, milk and beef. Table 3.1 shows that the majority of the farms are located relatively near to population centres. However the last 25% of them are located between 5 and 27 kms. There is a big variation in the size of the farm in both, total, and pasture areas as can be seen in the standard deviations and the difference between the 0% and 100% percentiles. The small difference between the total area and the pasture area and the small proportion of farmers with area dedicated to crops (percentile 100%) indicates the high level of specialisation towards dairy activities. Only 25% the farms preserve some areas in forests. The size of the herd range between 1 to 130 cows, with an average of 39 showing that the sample is a mixture of the small and medium size farms. This size is also reflected in the small amount of both, hired and familiar labour since 75% of the farmers used 2 or less labour from the two sources.

Table 3.1. **Variables related to dimension and land use**

variable	units	Mean	Std	Percentiles*				
				0%	25%	50%	75%	100%
Distance from cities	Kms	3.4	4.87	0	1	2	5	27
Total area	hectares	66.5	91.0	2	15	35	84	600
Pasture area	hectares	50.8	54.8	1	14	32	70	250
Crops area	hectares	1.8	6.4	0	0	0	0	50
Forest area	hectares	10.6	25.7	0	0	1	6	168
Number of milking cows	cows	39.3	25.0	1	20	33	53	130
Number of hired labour	unit	1.3	1.6	0	0	1	2	10
Number of family labour	unit	1.3	1.0	0	1	1	2	5

*0%= minimum value, 50%=median, 100%=maximum value

The figures in Table 3.2 provide evidence of the high level of milking and cooling facilities in the farms. Seventy eight percent have milking parlour. Only 15% made the milking by hand and the rest using vacuum machines, most of them with pipeline. The cooling systems consist of tank and few farmer do not have o used other kind the systems. These figures are in agreement with the marked exigencies in terms of milk quality and minimum facilities to qualified to sell the milk to dairy factories and co-operatives.

Table 3.2. **Variables related to equipment**

Variable	category	n	%	cum.	% cum.
Milking parlour	no	20	22	20	22
	yes	71	78	71	100
Milking machine	no	14	15.3	14	15.3
	container	33	36.2	47	51.5
	pipeline	44	48.3	91	100
Cooling system	none	9	9.8	9	9.8
	tank	75	82.4	84	92.2
	other	7	7.6	91	100
Number of tractors	none	71	78	71	78
	1	18	19.7	89	97.7
	2	2	2.2	91	100

3.4.2 Farmers

The variables used to characterise the farmers were the most commonly used biographical variables in literature. Age was used as a proxy of the level experience of the farmer, the family cycle stage and personal attitudes. Dedication to farming in hour per week was regarded as a proxy of presence of the farmer in the farm and indirectly as a proxy of the off farm activities. Although gender was included to account for differences between men and women. Finally educational level was included as proxy of the level of literacy, numeracy, and personal attitudes.

The population of farmers is relatively young, according to the mean and the percentiles. Seventy five percent of them were under 54 years old. On the other hand, they are highly dedicated to farming since only 25% reported to dedicate less than 30 hours a week. The majority of them work for more than 48 hours a week.

Table 3.3. Farmers' age and dedication to farming

variable	units	Mean	Std	Percentiles				
				0%	25%	50%	75%	100%
Age of farmer	years	45	12.6	21	37	43	54	75
Dedication to farming	hours/week	45	21.0	1	30	48	60	84

Respect of gender, the population is almost composed by male farmers (only 7 women farmers were found) with a high level of literate since only 11 farmers did not complete the primary. It is important of note that from the total sample, only one farmer was not able to read o write, therefore he was excluded (because some the tasks in the interview needed this skill). There was high proportion of the farmers with education from secondary to university, being the latter very high (27.5%) (Table 3.4).

Table 3.4. **Farmers' gender and educational level**

Variable	category	n	%	cum.	% cum.
Gender	Female	7	7.7	7	7.7
	Male	87	92.3	84	92.3
Educational level	none	11	12.1	11	12.1
	Primary	43	47.3	54	59.3
	Secondary	12	13.2	66	72.5
	Universitary	25	27.5	91	100

Table 3.5 demonstrates that technical advisor in animal science and veterinarians are used is the majority of farms, being the former often used in a monthly basis while the latter more occasionally. Only 15 farmer used technical agronomist mostly in occasionally. In general terms, 38% of farmers did not used any kind of technical advisors as managerial supports, while around a half of them used a combination of advisors in animal science and veterinarian. Finally, only 15% of farmers used the three types of advisors together.

Table 3.5. **The use of technical advisors**

Variable	category	n	%	cum.	% cum.
Technical advisor in animal science	never	35	38.8	35	38.8
	Occasional*	16	17.6	52	56.4
	Frequent**	40	44	91	100
Technical advisor veterinarian	never	35	38.5	35	38.5
	Occasional	46	50.5	81	89
	Frequent	10	11	91	100
Technical advisor agronomist	never	76	83.5	76	83.5
	Occasional	9	9.9	85	93.4
	Frequent	6	6.6	91	100
None		35	38.4	35	38.4
Animal science + veterinarian		42	46.1	77	84.5
Animal science + veterinarian + agronomist		14	15.3	91	100

*less than 12 visits per year, ** once or more per month

Very few farmers have no record keeping system (Table 3.6). The majority use manual record keeping while over a quarter have some computerised systems mostly VAMPP, which is a management information systems software developed by the Universidad Nacional in Costa Rica. This shows the high level of use of these tools in the country.

Table 3.6. Type and comprehensiveness of the record keeping systems

Variable	category	n	%	cum.	% cum.
Record keeping	none	8	8.8	8	8.8
	daily book	5	5.4	13	14.2
	general book	36	39.5	49	53.7
	individual files	8	8.8	57	62.5
	computer	8	8.8	65	71.3
	Vampp	26	28.5	91	100
Milk yield	No	56	62.2	56	62.2
	Yes	34	37.8	90	100
Reproductive events	No	8	8.9	8	8.9
	Yes	82	91.1	90	100
Replacements growth	No	61	67.8	61	67.8
	Yes	29	32.2	90	100
Diseases incidence	No	41	45.6	41	45.6
	Yes	49	54.4	90	100
Gynaecological exams	No	70	77.8	70	77.8
	Yes	20	22.2	90	100
California mastitis tests	No	57	63.3	57	63.3
	Yes	33	36.7	90	100
Pasture management	No	70	77.8	70	77.8
	Yes	20	22.2	90	100
Lameness problems incidence	No	62	68.9	62	68.9
	Yes	28	31.1	90	100

In respect to the comprehensiveness of the record keeping system, this table shows that the reproductive events are the data more extensively recorded by the farmers (82%). Disease incidences are the second most recorded events, followed by individual milk yield, California Mastitis tests, replacement growth, lameness problems, gynaecological exams, and pasture management, in this order. All these aspects are only recorded by

30% of the farmers or less. This result shows that, although the use of record keeping systems, including computerised information systems, is very high, the comprehensiveness is very narrow, mostly limited to reproductive events. The lack of individual milk yield records demonstrates the limited information available to the farmer for selection and nutritional management purposes that lead to an inefficient allocation of resources such as concentrates (see nutrition management section).

3.4.3 Management

Nutrition

Table 3.7 indicates the high level of energetic supplementation used in these farms. On the other hand, it is also shown that this supplementation comes, in a very large proportion, from concentrated foods and in a very small proportion from agricultural by-products. This demonstrated the high dependence of the farms from external inputs. This can be explained by the relative low costs of these foods when compared with the milk price ($0.17/kg a standard concentrate for milking cows, and $0.28/litre the milk price). Thereby, the farmers are strongly motivated by the profit of using concentrates.

Table 3.7. Energetic supplementation

Variable	units	Mean	Std	Percentiles				
				0%	25%	50%	75%	100%
Energy Supplemented	Mcal NE_l/day*	280.0	301.0	0	78	200	392	1609
Requirement supplemented	%	68.1	35.0	0	48	72	84	100
Requirement by concentrates	%	64.0	36.0	0	43	69	84	100
Requirement by by-products	%	7.1	4.8	0	3.6	6.6	9.9	20

* NE_l = Net energy for lactation expressed in calories.

Table 3.8. **Nutritional strategy**

Variable	category	n	%	cum.	% cum.
Supplementation strategy	null	8	8.8	8	8.8
	by-products	4	4.4	12	13.2
	by-products+concentrates	12	13.2	12	26.4
	Concentrates	67	73.6	91	100.0
Number of feeding strata	1	70	76.9	70	76.9
	2	16	17.6	86	94.5
	3	4	4.4	90	98.9
	4	1	1.1	91	100.0
Milk/concentrate ratio	none	62	68.1	62	68.0
	3	19	20.8	81	88.8
	2	10	10.9	91	100.0

Table 3.8 shows two thirds of the farmers use concentrates as sole form of supplementation while rest use supplementation with agricultural by-products or combination with concentrates. Only 23% of the farmers use more than one group of cows for feeding and around 30% use milk/concentrate ratio to measure the amount of concentrate to be offered to the cows. This indicates the relatively inefficient use of the food resources since the majority of the farmers use a flat rate regardless of milk yield. As discussed before, the lack of records of individual milk yield could be constraining the implementation of better nutritional strategies.

Pasture management

According to Table 3.9, improved pastures are extensively used in the sample. Only 25% of them have less than 60% of improved pasture species such star grass (*Cynodon nlenfluensis*) and kikuyu grass (*Pennisetum clandestinum*). Relatively high level of fertilisation can be found, especially Nitrogen ranging from 0 to 500 kg per hectare per year. This level of fertilising is related to the relative low cost of this inorganic element in Costa Rica ($0.21/kg). Fifty percent of the farmers use fertilisation with phosphorus and potassium mostly from complete formulas 10/30/10 (NPK) with higher costs ($0.27/kg) than nitrogen.

The stocking rate showed a high variation as demonstrated by the mean and standard deviation. These parameters demonstrate that the majority of the farmers use relatively high stocking rates (a Holstein of 600 kg=1.3 animal units). Obviously, both fertilisation level and stocking rates are very related to regional environments. For example Pacific region has a 6 months dry season that constrains the use of fertilisation and the stocking rates used. These seasonal differences along with differences in soil quality also define the pasture species and thereby the effect of fertilisation.

Table 3.9. Proportion of improved pastures, fertilisation and stocking rate

variable	units	Mean	Std	Percentiles				
				0%	25%	50%	75%	100%
Improved pasture	%	79.4	29.4	0	60	100	100	100
Nitrogen	kg/ha/year	151.7	250.4	0	13	95	216	500
Phosphorus	kg/ha/year	44.3	87.0	0	0	16	61	90
Potassium	kg/ha/year	24.6	43.5	0	0	11	38	60
Stocking rate	Animal units	2.7	1.8	0.2	1.4	2.4	3.3	10.6

Reproduction

In respect of reproduction management, Table 3.10 indicates that artificial insemination is more extensively used in cow than in heifers. 42% and 36% of the farmers used only artificial insemination on cows and heifers, respectively, while 12% and 5% use a combination with natural mating. Nevertheless, the proportion using 100% of natural mating is also quite high with heifers. This table also shows that the use of artificial devices for heat detection is very limited since only 4.5% use.

The use of intra-uterus antibiotics treatments and hormones for heat induction are the most extensively used practices during the post-calving period of the cows. Other practices such as heat synchronisation in cows and heifer are relatively less used, since only around 15% and 10% of the farmers used this technology in heifers and cows, respectively. Only 4 farmers used embryo transfer.

Table 3.10. Use of artificial insemination and heat detetion

Variable	category	n	%	cum.	% cum.
% artificial insemination in cows	null	32	35.5	32	35.5
	<75%	12	13.3	44	48.8
	>75%	38	42.2	90	100
% artificial insemination in heifers	null	43	55.8	43	55.8
	<75%	5	1.3	44	57.1
	>75%	29	36.4	77	100
Heat detection devices	No	86	95.5	86	95.5
	Yes	4	4.5	90	100

Table 3.11. The use of reproductive treatments

Variable	category	n	%	cum.	% cum.
Intra-uterus antibiotics treatment	No	29	32.2	29	32.2
	yes	61	67.8	90	100
Hormones for heat induction	No	51	56.7	51	56.7
	yes	39	43.3	90	100
Heat synchronization in heifers	No	76	84.4	76	84.4
	yes	14	15.6	90	100
Heat synchronization in cow	No	81	90	81	90
	yes	9	10	90	100
Embryo transfer	No	86	95.6	86	95.6
	yes	4	4.4	90	100

Health

In respect to diagnosis and prevention of mastitis, Table 3.12 shows that most of the recommended practices towards improvement of milk quality and prevention of mastitis have been highly adopted by the farmers. Disinfecting the teats after milk is used by 65% of the farmers. These farmers could be related to the proportion of dual-purpose farms where this practice can not be used because of the suckling of the remaining milk by the calf. Washing the udders before milking is almost universal. Drying the teats

before milking is also frequent. However the biggest proportion of the farmers share towels/tissues for all or some cows while those farmers using them individually are less.

Table 3.12. Prevention and diagnosis of mastitis

Variable	category	n	%	cum.	% cum.
Disinfecting the teats after milk	No	31	34.4	31	34.4
	yes	59	65.6	90	100
Washing the udder before milking	No	7	7.8	7	7.8
	yes	83	92.2	90	100
drying the teats before milking	not use	18	20	18	20
	shared towels/tissue	46	51.1	64	71.1
	Individual towel/tissue	26	28.8	90	100
Applying antibiotics when drying out a cow	No	21	23.3	21	23.3
	yes	69	76.7	90	100
Adjusting vacuum pump	No	32	35.6	32	35.6
	Yes	58	64.4	90	100
Frequency of CMT	null	31	34.4	31	34.4
	+30 days	12	13.4	43	47.8
	15-30 days	35	38.8	78	86.6
	-15 days	12	13.3	90	100

Applying antibiotics when drying out a cow commonly practised, since only 20% of farmers do not use them. Adjusting vacuum pump pressure was not adopted by 35% of the farmers. Nevertheless these farmers include those not using milking machine (14 farmers). This shows that this practice is also almost generalised. Finally, the frequency of CMT indicates that 60% of the farmers have implemented this practice, the majority of them in a monthly or greater frequency.

Since all this practices are directly or indirectly related to the milk quality, these results show the high level of agreement between the market requirements and the level of use of these practices throughout the country.

Table 3.13. **Prevention of lameness problems**

Variable	category	n	%	cum.	% cum.
Hoof-trimming	never	34	37.7	34	37.7
	once a year	12	13.1	46	50.1
	when problems arise	31	34.4	77	85.2
	Periodically	13	14.4	90	100
Foot-baths for lameness problems prevention	No	51	56.7	51	56.7
	Yes	39	43.3	91	100
Quality of internal roads for cows	Natural ground	34	37.7	34	37.7
	Gravel	24	26.6	58	64.3
	Cement/asphalt	32	35.5	90	10

Practices to prevent lameness problems such as hoof-trimming and the use foot-baths have been less adopted by the farmers (Table 3.13). The majority of them never use hoof-trimming or use it only when problems arise. A small proportion use it periodically or once a year when the cows are dried out or after the calving. Foot-baths are only used by 43% of the farmers. This table also demonstrate that a big proportion of the farmers have invested in road for the cows as way of preventing lameness problems using gravel and mostly cement or asphalt.

These result shows that, while big effort have been directed to diagnosis and prevention of mastitis, less attention have been direct to prevention of lameness problems.

Productivity

Table 3.14 shows the high variation in the productive parameters. The small difference between total milk yield and milk sales demonstrates the low level of self-consumption and the commercial orientation of the farms. The milk per cow per day shows the relative low milk yield since 75% of the farms produce less than 15 kg a day. These figures seem to be low if the genetic and nutrition management, already explained, are taken into account. The intensification level of the farms, represented by milk yield per hectare per year, shows a very high variation evidenced by the difference between the 0% and 100% percentiles.

Table 3.14. Some productive parameters

variable	units	Mean	Std	Percentiles				
				0%	25%	50%	75%	100%
Total milk yield	kg/day	496	436.4	59	180	367	610	2240
Total milk sales	kg/day	470	420.3	55	170	335	600	2200
Milk yield/cow/day	kg/day	11.8	5.6	2.7	7.8	11.8	15.0	27.5
Milk yield/hectare/year	kg/year	7696	7630	213	2120	5596	9835	36500*

*a farm with 13 cows producing 15 kg/day in 2 hectares with high supplementation of concentrates (5.5 kg/cow/day) and banana peel (20 kg/cow/day)

The economic parameters presented in Table 3.15 shows that feeding costs represents around 62% of the input purchases costs, followed by labour (28%) and fertiliser costs. This relation is preserved as the production costs increases throughout the percentiles.

Table 3.15. Some economic parameters

Variable	units	Mean	Std	Percentiles				
				0%	25%	50%	75%	100%
Fertiliser costs	$/day	5.0	6.2	0	0.6	3.0	6.75	30.5
Labour costs	$/day	13.9	17	0	0	9.7	22.5	100
Feeding costs	$/day	30.0	32	0	8.5	20	41	188
Total cost	$/day	48.9	48.4	0	13	34	67	240
Income	$/day	131.6	117.8	15.4	47.6	93.8	168	616
Margin*	$/day	82.7	75.9	-2.0	32	57	106	420
Margin/cow/day	$/day	2.1	1.02	-0.1	1.3	2.05	2.7	5.4
Margin/hectare/day	$/day	3.6	3.7	-0.1	0.87	2.66	4.5	24.3
ROWC**	%	64.3	17.4	-7.1	54.3	63.9	76.1	100

*margin over feed, labour and fertiliser; **rate of return on working capital

The economic results represented by the margins show that the 75% of the farmers receive more than $32 a day or $972 a month of margin over feeding, labour and fertilisers costs. This shows that the activity provides the farmers the income necessary to have a relatively good standard of living, taking into account the living costs in the country. The rate of return on working capital also shows to be high in all the percentiles (except the 0%). The farms that obtained a 100% rate were those where no

supplementation or fertilisation are used and where only familiar labour was used. All the parameter shows a high variation throughout the population evidenced by the high standard deviations respect to the means

3.5 Concluding remarks

From all the information analysed, the sample of farmers could be characterised as follows: Specialised dairy farms without crops. It is a mixture of small and medium farms, with low familiar and hired labour. They have high level of facilities for milking and cooling as a response of the market demands. These farms are managed by young, dedicated farmers, mostly males with high literacy levels, much of them with secondary and universitary education, and supported by private technical advisors, mostly animal scientists and veterinarians. They use record keeping systems, many of them computerised (VAMPP) but with limited comprehensiveness towards reproductive events. Nutrition is highly dependent for external inputs mainly concentrates which are offered in flat rates. Grazing is based on improved pasture species such as star grass and kikuyu grass with high level of nitrogen fertilisers and complete formulas (NPK) managed with relatively high stocking rates. Reproduction is mostly based on artificial insemination, using antibiotic and hormonal treatments during the post-calving period. A high level of adoption towards diagnosis and prevention of mastitis are also found as another response to the market exigencies and milk prices. However, less attention is paid to the prevention of lameness problems. On average, low milk yields are found in the population. However high variation exists in all the productive and economic parameters. Nevertheless the majority of the farmers obtain a margin enough to provide a relatively (to the Costa Rican standards) good standard of living.

Chapter 4 Characterising objective profiles of Costa Rican dairy farmers[***]

Abstract

Farmers' objectives and the factors affecting them were studied in 91 dairy farms in Costa Rica. Objective hierarchies were studied using a Rokeach's technique with a mixture of personal, economic and familiar goals. The overall ranking of objectives was obtained by calculating the arithmetic means of each objective. A canonical correlation analysis (CCA) was performed to find out simple and canonical correlations between farmers'/farms' characteristics and objective priorities. Factor Analysis (FA) combined with a Cluster Analysis (CLA) were used to reduce the number of variables involved and define groups of farmers with similar economic, personal and familiar and overall objective profiles.

Results showed that economic goals such as '*Producing high quality products*', '*Obtaining a satisfactory income*', '*Maximising annual revenue*' and '*Maximising incomes*' are the most important objectives for the majority of farmers. Low to medium significant simple correlations and one medium to high canonical correlation were found showing that age, educational level, distance of the farm to population centres, the level of dedication and pasture area were the characteristics that had the biggest impact on the arrangement of objectives. The FA and CLA found 6, 7, 7 and 10 groups of farmers for the economic, personal, familiar and overall objectives respectively. The overall cluster analysis showed that economic oriented farmers were more frequent in the population. However, farmers with personal and familiar profiles were also found.

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[*] based on Solano, C., Herrero, M., León, H. and Pérez, E. (2000) Characterising objective profiles of Costa Rican dairy farmers. Agricultural Systems. (submitted).

[**] The contribution of the co-authors in the papers from which chapters 4, 5, 6 and 7 are based, provided guidance, comments and discussion. All the papers are product of work made by the author.

4.1 Introduction

The literature review in chapter 2 showed the considerable progress of the Farming Systems Research in terms of characterisation methodologies and simulation models. However it also demonstrated the oversimplification of the human component of the systems and its consequences on the impact of the discipline in producing agricultural development. One of these oversimplifications comes from the assumption that the farmer acts almost exclusively towards maximisation of the biological and financial outcomes of the farm. From studies reviewed, it was concluded that it was necessary to obtain more empirical proofs (especially from developing countries) of hierarchies of goals, the factors affecting them, and the population patterns and to propose more methodological approaches to improve the state of the art in matter.

This chapter is an attempt to characterised the objective hierarchies of the Costa Rican farmers, study the factors affecting these orientations, and to define profiles that can be used to study their impact on the management and performance of the farm (chapter 7).

4.2 Materials and methods

4.2.1 Rokeach's technique

In order to record the hierarchies of objectives of the farmers, a Rokeach's technique (Foddy, 1993) was used. Farmers were provided with 17 labels, each one representing an objective. They were instructed to order them from the most important one, at the top of the sort, to the less important one at the bottom of it. The statements were a mixture of economic, personal and familiar objectives selected from literature and brain storming of the team conformed by investigators at Institute of Ecology and Resource Management, University of Edinburgh and Universidad Nacional in Costa Rica (Table 4.1). There was not limit of time for the farmer to finish the task. This exercise is showed in Figure 4.1.

Table 4.1. List of objectives evaluated

Objective definition	Code
Economic	
Maximising incomes (cash flow)	MAXI
Having satisfactory incomes	INCS
Re-investing in the farm	INVE
To expand the business	EXPA
Maximising annual net revenue	MAXR
Saving money for the retirement	MONR
Producing high quality products	PROQ
Saving money for children education	EDUC
Personal	
Reducing work and effort	REDW
Reducing risks	REDR
Gaining recognition among other farmers	RECO
Being innovative	INNO
Having time for other activities	TIMO
Producing environmentally friendly	ENVI
Familiar	
Pass the farm to the next generation	INHE
Maintaining the standard of living	LSMA
Improving standard of living	LSIN

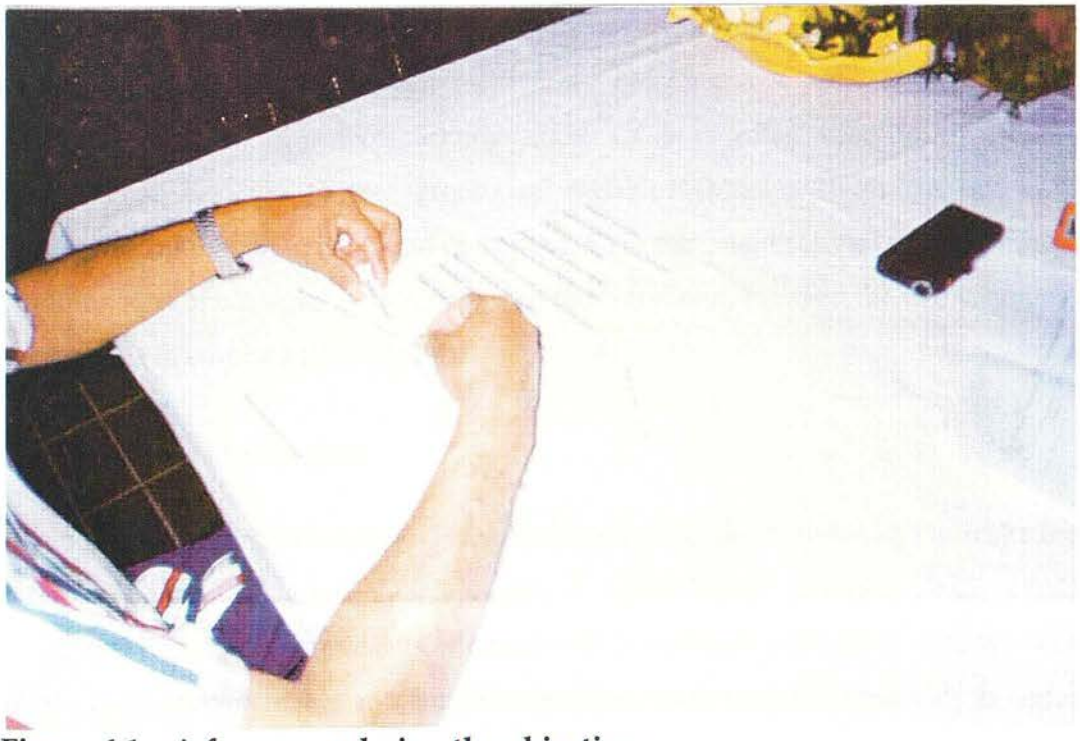

Figure 4.1. A farmers ordering the objectives

4.2.2 Ranking of objectives

Using arithmetic means, an overall ranking of the objectives in the country was obtained. The standard deviations were used as indicators of the level of dispersion throughout the population. The same analysis was performed for each geographical region in order to find out differences throughout the country. A Duncan test was used to compare the means of each objective throughout the regions to identify those objectives with high variation. The Duncan test is a multiple comparison method that given more information about the differences among means. It uses step-down, multiple stages tests of homogeneity among all the possible combinations of pairs (SAS, 1994).

4.2.3 Relationships between farmers'/farms' characteristics and objectives

A Canonical Correlation Analysis (CCA) (SAS, 1994) was used to analyse the correlation matrix between the farmer's/farms' characteristics and the 17 objectives. Farmers' characteristics were: age (years), working hours in the farm (hours/week), and educational level (none, primary, secondary, technical and universitary). Farms' characteristics were: distance to population centres (kms), and pasture area (has). This analysis produced both: simple correlations among all the variables and canonical correlation between different combinations of farmers'/farms' characteristics and objectives arrangements. CCA is often used to investigate relationships between to two groups of variables (Manly, 1994) (in this case farmers'/farms' characteristics and objective). Each the canonical variables is a linear combinations of each group of variables so the correlation between the two canonical variables is maximised (SAS, 1994).

4.2.4 Factors of objectives

In order to reduce the number of variables involved in the analyses and to make the interpretation of the arrangements easier, A series Factor Analyses (SAS, 1994) using the Principal Components Method with a Varimax orthogonal rotation was used. Economic, personal and familiar objectives were analysed separately in order to avoid very complex interpretations and obtain separated profiles. In this way it

was possible to account for a high proportion of the original variance and obtain 3-dimensional graphics, that besides the statistical methods, made it easier finding the best number of groups in which the population in naturally divided. Factor scores by farm were calculated and used instead of the original variables.

4.2.5 Clustering the farms according to their objectives

Because there are several clustering methods and their performance depends on the nature and dispersion of the data, nine methods were evaluated. Average linkage, Centroid, Complete linkage (further neighbour), Maximum-likelihood hierarchical method, Flexible (Lance-Williams flexible method), Median (Gower's median method), McQuitty similarity analysis, Single (nearest neighbour) and Ward's minimum-variance method (SAS, 1994) were included. The performance of each clustering method was measured by looking for the best number of clusters according to a consensus of four statistics: high Determination coefficient (r^2), a peak in the Cubic Clustering Criterion (CCC) and Pseudo F statistic (PsF) and a small value of Pseudo T statistic (PsT) (SAS, 1994). Scatter graphics of farms in the 3-dimensional Eucledian space (each dimension representing an economic objectives factor) were drawn to visually evaluate the performance of each method. Once the best method was identified, cluster analyses were repeated for personal and familiar objectives factors.

4.2.6 Farmer profiles

Although the Factor analysis transformed the three sets of objectives into few, independent, normally distributed and 3D-graphicable variables, no straightforward interpretations of each cluster can be done using factor's scores directly. This is because, for example, the farmer with the lowest score in any factor was indeed the farmer who ranked higher or lower the objectives correlated to this factor. However, due to the ranges of these objectives within the sample, low scores could not necessarily mean that their correlated objectives were ranked near to 1 or 17. In order to avoid these problem, the interpretations of cluster's affinity or oppositeness to different objectives was made by looking at the actual Least Square Means (Lsm)

and Confidence limits (CL) (alpha=.10) of each objective within each cluster (Appendix 2). These statistics were calculated using a General Linear Model with objectives and clusters as dependent and independent variables respectively. Depending on the values of these statistics, traits were assigned to each cluster to describe the farmers' economic, personal and familiar profiles. Then label were assigned to each profile for subsequent analyses.

4.2.7 Overall factors and clusters

In order to obtain more general profiles, taking into account all the objectives together, the nine factors representing the three groups of objectives, were introduced into a second factor analysis. This produced factor scores that represent the overall objective hierarchy of each farmer. A second Cluster Analysis grouped those farmers with similar hierarchies. Calculating the Least Square Means of each objective within each cluster, the hierarchies of objectives by group were calculated. Interpretations were based on the first 5 and the last 5 objectives in the hierarchy.

Figure 4.2 is a diagram that summarises all the methodology used in this study.

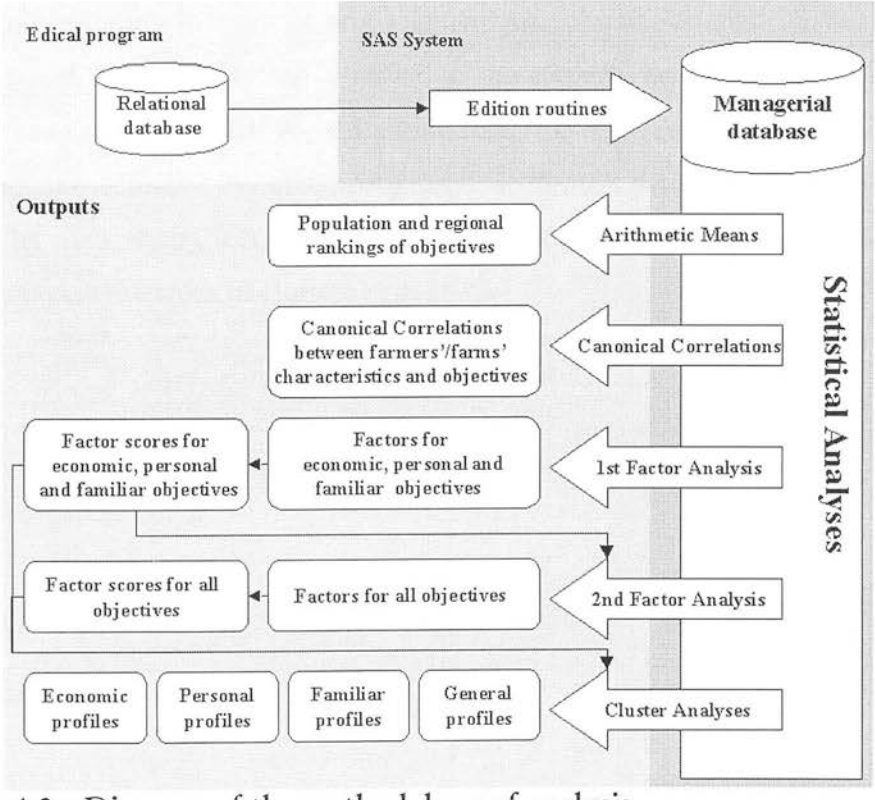

Figure 4.2. Diagram of the methodology of analysis.

4.3 Results and discussion

4.3.1 Ranking of objectives

Table 4.2 shows the ranking of objectives at country level and in different regions throughout the country.

'*Producing high quality products*' was the most important objective for Costa Rican dairy farmers. This could be easily explained by the fact that all the participating farmers belonged to dairy co-operatives and dairy product factories. These companies pay different prices for different milk qualities taking into account somatic cells counts and total solids in milk. Some extra-payments for high fat and protein contents are also usually made. PROQ can be regarded as an instrument to obtain other economic objectives such as INCS, MAXR, MAXI and EXPA which were ranked in second, third, fourth and fifth place respectively. These results show that, in general, Costa Rican farmers are economically motivated but not necessarily they are optimiser since *'Having a satisfactory income*' was ranked in second place and because highly ranked *EXPA*. This shows that maximisation was related to the desire of expanding in terms of area and herd size. An explanation for this desire to EXPA could be the marketing situation of the country. International markets have been opened and, as a consequence, exportations have increased and milk quotas had not effect at the time of the study. As a response farmers perceived the opportunity of increasing incomes by increasing volume of milk produced. These aspects are well documented in the work of Herrero *et al* (1999).

Table 4.2. Ranking of objectives in Costa Rica and different regions

Country			Pacific			Northern			Central Oriental			Central Occidental		
Objec.	Mean	Std	Objec.	Mean	Std	Objec,	Mean	Std	Objec,	Mean	Std	Objec,	Mean	Std
PROQ	4.26	3.50	MAXI	4.31	2.66	PROQ	4.26	3.55	PROQ	4.40	3.89	PROQ	3.68	3.05
INCS	6.42	3.87	PROQ	5.23	4.00	INCS	6.76	3.89	MAXR	4.40	3.31	MAXR	6.28	4.09
MAXR	6.46	4.12	INCS	5.31	3.79	MAXR	6.88	4.26	MAXI	4.50	2.59	INCS	6.40	3.58
MAXI	6.49	4.27	EDUC	6.85	4.49	EXPA	7.07	4.37	INVE	5.90	5.13	LSIN	6.88	5.11
EXPA	7.42	4.61	MAXR	7.00	4.22	MAXI	7.10	4.60	EXPA	6.20	4.69	MAXI	7.40	4.43
ENVI	7.81	4.52	EXPA	7.31	4.57	ENVI	8.10	4.66	INCS	6.50	4.84	ENVI	7.56	5.07
LSIN	8.20	4.87	LSIN	7.38	4.27	INVE	8.12	4.48	ENVI	7.30	3.40	INVE	8.56	3.11
INVE	8.54	4.26	ENVI	7.77	4.13	REDR	8.38	4.33	INNO	7.50	3.14	EXPA	8.56	5.03
EDUC	9.12	4.91	INHE	9.08	5.31	LSIN	8.40	4.63	REDR	9.20	2.90	MONR	9.16	4.77
REDR	9.17	4.02	MONR	9.54	5.38	INNO	8.71	4.09	REDW	10.30	4.47	EDUC	9.20	5.49
INNO	9.37	4.31	REDR	9.77	3.88	EDUC	8.79	4.70	INHE	11.30	4.57	INNO	10.00	4.04
MONR	10.01	4.72	TIMO	10.08	3.48	MONR	9.93	4.76	LSMA	11.60	3.84	REDW	10.16	4.39
LSMA	11.11	4.48	LSMA	10.92	4.37	REDW	10.98	3.89	TIMO	11.60	4.22	REDR	10.16	3.88
REDW	11.26	4.14	INNO	11.69	5.41	TIMO	11.33	3.62	LSIN	11.70	4.81	LSMA	10.32	4.47
INHE	11.31	4.65	INVE	11.92	2.87	LSMA	11.52	4.73	MONR	13.10	2.18	INHE	11.64	3.93
TIMO	11.40	3.80	RECO	13.92	2.87	INHE	11.81	4.81	EDUC	13.30	1.83	TIMO	12.12	4.11
RECO	14.36	3.68	REDW	15.00	1.73	RECO	14.57	3.71	RECO	14.20	3.55	RECO	14.28	4.19

'*Producing environment friendly*' was ranked high (6th) showing that environment issues were important for Costa Rican farmers. It could be explained by the educational and political efforts towards environmental protection and sustainability of the production processes in the country.

In the middle of the ranking familiar objectives were preponderant. '*Improving standard of living*' objective was ranked in seventh place and higher than '*Maintaining the standard of living*' (13th) showing that farmers were not satisfied with their standard of living but they wanted to improve it. '*Re-investing in the farm*' was ranked higher than 'Saving money for the retirement' showing that they wanted to be investors rather than savers.

'*Saving money for children education*' ranked in 9th shows that this very specific objective is less important than more general familiar objectives possible due to the education Costa Rica is free from primary school to the first degree at the University. '*Reducing risks*' and '*Being innovative*' were ranked in 10th and 11th place respectively, demonstrating that in general farmers tended to be neutral respect to risk taking and innovations. However, it should be said that farmers had problems in understanding the meaning of the statement '*Reducing risks*'.

'*Pass the farm to next generation*' was ranked very low. This could be explained by fact that, due to the normal distribution of the variable, the majority of farmers were young, so this issue was not very important for them. '*Reducing work and effort*', '*Having time for other activities*' and '*Gaining recognition among other farmers*' were the less important objectives for them, demonstrating their interest in working hard and to be dedicated to in-farm work. An explanation for the last objective could be that they were bounded to express their real point of view.

Looking at different regions (Table 4.2) it seems that the most important objectives, with very small differences, were the same than at national level. With the exception of the Pacific region, PROQ continued being the most important objective. All regions except the Northern region try to maximise either MAXING or MAXR. It is clear that farmers in the central area of the country (peri-urban farmers) were more entrepreneurial since MAXR was ranked higher than MAXING and

INCS. Environmental issues were still very important regardless of the region they belong to, while RECO was still the less important one.

Looking at Duncan test of means, only INVE, EDUC, INNO, REDW and EXPA were statistically different ($P<0.10$) showing their variability at inter-regional level. INVE, INNO and REDW were ranked low in the Pac region, which is related to traditional farming approaches in that region. In the Cori region EDUC, REDW were ranked lower while INNO was ranked higher probably due to the entrepreneurial and high-tech farming orientation of the farmers in this region. EXPA was relatively low in Cocc which could be a result of the very expensive land prices and the high intensification level in this region making it difficult to expand in terms of land and herd size.

4.3.2 Relationships between farmers'/farms' characteristics and objectives

Since objectives were ranked from 1 to 17, it means that the closer to 1 the more important objectives are. Hence correlations in Table 4. 3 should be interpreted in an opposite way than the sign except for the farmers'/farms' characteristics. This table shows the simple correlation among several farmers'/farms' characteristics and objectives' importance.

The analysis demonstrated that older farmers were attached to INHE, LSMA, TIMO and ENVI whilst they were against EXPA, showing the natural desire of inheritance and of stability from the familiar and farming point of view. At the same time they wanted to have more time for other activities different than farming probably as a way of resting. They were more interested in environmental issues than younger farmers. An explanation of this result could be that older farmers know better their production systems, have more experience and tend to manage the farms in such a way that they survive through time (Thornton, personal communication). These results are in agreement with the results reported by Perkin and Rehman (1994) in the sense that age is correlated to life style objectives. However they are clearly opposed since in their study age was negatively correlated to the desire of having time for other activities. These findings do not agree with results of Austin *et al* (1996) in which younger farmers were entrepreneurial since no correlations between age and maximising revenue or incomes were found.

Table 4.3. Correlation matrix between objectives and farms'/farmers' characteristics

Objectives	Characteristics				
	Distance	Age	Dedication	Pasture area	Education
Distance	1.0000	0.2325	0.0573	0.2911	0.0292
Age		1.0000	-0.0878	0.2115**	-0.2528**
Dedication			1.0000	-0.0421	-0.3479***
Pasture area				1.0000	0.0711
Education					1.0000
INHE	-0.0102	-0.1890*	-0.1629	-0.1433	0.1054
EDUC	-0.0523	0.0368	0.0192	-0.2471**	-0.0175
LSMA	-0.0071	-0.1849*	-0.0336	0.1599	0.2549**
REDW	0.1384	0.0617	-0.0337	0.3392***	-0.0116
REDR	0.0053	-0.0618	0.0457	0.0681	-0.1187
LSIN	0.0818	0.0085	0.0084	-0.0699	0.0502
RECO	-0.0193	-0.0000	-0.1194	0.0937	0.1088
INNO	0.1695	0.0288	0.2673**	-0.0669	-0.2489**
TIMO	-0.2876***	-0.1794*	-0.0726	-0.0064	0.1929*
ENVI	-0.1038	-0.2173**	0.1818*	0.0511	-0.0662
MAXI	-0.1845	-0.0178	-0.0056	-0.0839	-0.0691
INCS	-0.1305	-0.0283	-0.0253	-0.2248**	0.1565
INVE	0.1376	0.1654	0.0804	0.0683	-0.2619**
EXPA	0.0843	0.3108***	-0.0211	-0.0232	0.0273
MAXR	0.0310	0.0913	0.0060	-0.0044	-0.1539
MONR	0.1265	0.0048	-0.1018	0.0374	0.0815
PROQ	-0.0094	0.1444	-0.1049	0.0648	-0.0207

* P<0.1, **P<0.05, ***P<0.01

Farmers with higher education tend to rank LSMA low, showing that they did not want to maintain their standard of living. However they were not identified with '*Improving the standard of living*'. As an explanation of that could be that highly educated farmers are likely to have other activities (which was proved by the inverse correlation between educational level and dedication to farming) so they disassociate the familiar situation from the farm. They tended to be identified with '*Being innovative*' *and* '*Re-investing in the farm*' but against '*Having time for other activities*'. It seems to be a contradiction in the latter objective because of the inverse correlation between education and dedication to farming, however it could be explained by the fact that they already had this time for other activities so they considered this objective less important.

Other farmers'/farms' characteristics had very small correlation with the objectives' importance. The distance of the farm to population centres is only correlated with TIMO showing that the farther the farm, the more important '*Having time for other activities*' is. This could be explained by the necessity of having more time for travelling and social contact outside the farm. There was a positive correlation between distance and age, so farmers in distant farms were probably older and therefore they ranked TIMO higher.

More dedicated farmers tended to be less identified with INNO and ENVI. However this interpretation should be made in the scope of the correlation between educational level and dedication, so more dedicated farmers have probably lower educational levels and therefore these two objectives become less important for them.

Finally, the bigger the farm the more important EDUC and INCS and less important REDW were. There was not an obvious explanation for this finding.

These results show that the personal characteristics i.e. Age and Educational level and the farm size influence more strongly the objective arrangements of the farmer. It was also demonstrated that simple correlations were not efficient in explaining these relationships because there were some important correlations among the farmers'/farms' characteristics that interacted in defining the objectives priorities.

The Canonical Correlation Analysis found that only the first pair of canonical variables had a significant medium to high correlation (0.598, $P<0.05$). Correlations between the two groups of variables (farmers'/farms' characteristics and objectives) and their respective canonical variables were examined in order to interpret this relationship (Table 4. 4).

Table 4.4. Correlation matrixes of farmers'/farms' characteristics and objectives with their respective canonical variables

Canonical variables of Farmers'/farms' characteristics					
	FCV1	**FCV2**	**FCV3**	**FCV4**	**FCV5**
Distance	0.1122	0.6088	0.0851	0.2749	0.7308
Age	0.4680	0.3892	0.7657	-0.1831	-0.0982
Dedication	0.1980	0.2090	-0.5003	-0.7844	0.2273
Pasture Area	-0.7107	0.5163	0.4105	-0.2177	0.1114
Education	-0.3487	-0.6650	0.3246	0.1334	0.5595
Canonical variables of objectives					
	OCV1	**OCV2**	**OCV3**	**OCV4**	**OCV5**
MAXI	0.0455	-0.1412	-0.0609	-0.0904	-0.5363
INCS	0.2287	-0.4908	0.0395	-0.0249	0.0935
INVE	0.1741	0.5103	-0.0071	-0.0365	-0.1823
EXPA	0.3675	0.0216	0.5097	-0.1473	0.1991
INHE	-0.0409	-0.2349	-0.2070	0.5789	0.0655
MAXR	0.1321	0.2251	0.0030	0.0504	-0.2549
MONR	-0.0437	0.0482	0.1019	0.3057	0.3128
EDUC	0.3927	-0.2129	-0.0628	0.0480	-0.0382
PROQ	0.0171	0.0757	0.3087	0.0608	-0.2394
RECO	-0.1957	-0.0777	0.2047	0.1074	-0.0034
INNO	0.3024	0.4039	-0.3918	-0.2103	0.2237
REDR	-0.1320	0.2079	-0.1971	-0.0050	-0.2006
LSMA	-0.4697	-0.2147	0.0079	-0.0524	0.4359
REDW	-0.3990	0.3992	0.2221	-0.0480	0.1074
LSIN	0.1388	-0.0438	-0.0091	0.0903	0.3282
TIMO	-0.3249	-0.5122	0.0032	-0.1526	-0.3156
ENVI	-0.2712	0.0140	-0.4477	-0.3345	-0.1392
Correlation	0.5981	0.5582	0.5082	0.4141	0.3231
Pr>F	0.0406	0.1648	0.4246	0.7291	0.8072
PredP	0.0642	0.0794	0.0577	0.0271	0.0192

PredP is the variance of OCV explained by FCV (prediction power)

Using a correlation threshold equal to |0.30| the canonical variables could be interpreted as follows:

The Canonical variable of the Farmers'/farms' characteristics (FCV) was a contrast of Pasture area (-0.71), Educational level (-0.35) and Age (0.46). The Canonical variable of objectives (OCV) was a contrast of LSMA (-0.47), REDW (-0.40), TIMO (-0.32) and EDUC (0.39), EXPA (0.36) and INNO (0.30). This result showed that as the farm Area and the Educational level decreased and the Age increased, '*Maintaining the standard of living*', '*Reducing work and effort*' and '*Having time*

for other activities' became more important. '*Saving money for children education*', '*To expand the business*' and '*Being Innovative*' became less important. These results apply the other way around for young highly educated farmers in big farms. With this finding it was demonstrated that age, farm size and educational were the characteristics that had the biggest effect on the objectives priorities and that objectives change in time as a response of ageing. Explanations for these relationships are quite obvious in terms that older farmers tend to be more stable in the farm business and their standard of living and that his/her responsibilities as parents decline as children grow up. Finally, there is a natural desire of resting as the age increases.

The fact that FCV did not take into account the variable of Dedication proved that this variable did not have a real effect on the objective importance, but on their correlated variables.

It should be said that because of the small proportion of OCV variance that was explained by FCV (Table 4.4), the prediction power of this relationship in very small. Other variables should be taken into account in order to increase the predictability of objective priorities from farmers'/farms' characteristics.

Finally it was demonstrated that the Canonical Correlation Analysis was more efficient than the simple correlation analysis in uncovering the real relationships between farmers'/farms characteristics and the objective priorities.

4.3.3 Objective factors

Table 4.5 shows the rotated factor patterns for economic, personal and familiar objectives.

Table 4.5. Rotated factor patterns for economic, personal and familiar objectives, its eigenvalues and determination coefficients.

Objectives	Factors								
	Economic			Personal			Familiar		
	FE1	FE2	FE3	FP1	FP2	FP3	FF1	FF2	FF3
MAXI	-0.03	0.79	-0.19	-	-	-	-	-	-
INCS	0.07	0.19	0.57	-	-	-	-	-	-
INVE	0.74	-0.16	0.19	-	-	-	-	-	-
EXPA	0.21	-0.31	0.68	-	-	-	-	-	-
MAXR	-0.04	0.66	0.14	-	-	-	-	-	-
MONR	-0.77	-0.14	0.04	-	-	-	-	-	-
EDUC	-0.27	-0.37	-0.29	-	-	-	-	-	-
PROQ	0.48	-0.05	-0.62	-	-	-	-	-	-
INNO	-	-	-	0.10	0.20	-0.73	-	-	-
REDR	-	-	-	0.76	0.24	-0.08	-	-	-
REDW	-	-	-	-0.21	0.77	0.15	-	-	-
TIMO	-	-	-	0.13	0.23	0.79	-	-	-
ENVI	-	-	-	0.73	-0.36	0.16	-	-	-
RECO	-	-	-	-0.34	-0.65	0.19	-	-	-
INHE	-	-	-	-	-	-	0.03	1.00	0.08
LSMA	-	-	-	-	-	-	1.00	0.03	-0.06
LSIN	-	-	-	-	-	-	-0.06	0.08	1.00
Eigenvalue	1.53	1.39	1.30	1.34	1.28	1.21	1.17	1.04	0.79
Difference	0.14	0.09	0.27	0.06	0.07	0.42	0.13	0.26	
Proportion	0.19	0.17	0.16	0.22	0.21	0.20	0.39	0.35	0.26
Cumulative	0.19	0.36	0.53	0.22	0.44	0.64	0.39	0.74	1.00

Economic factors

For the economic objectives, FE1 was a contrast between INVE and MONR, showing that these objectives were contrary. Therefore farmers with low scores in this factor were investors rather than savers (*Investors*)[farmers with high scores should be considered *Savers*]. FE2 was related to MAXI and MAXR and negatively related to EDUC demonstrating the one-dimensionality of the two first variables and that the desire to maximising was slightly opposed to EDUC (*Maximisators-entrepreneurs*)[*Non-maximisators-Pro-family*]. These relations could be explained by the similarity between MAXI and MAXR for the farmers (several of them did not differentiated one from the other) and that more entrepreneur farmers (lower scores) disassociate revenue with saving money for the family. FE3 was a contrast between INCS and EXPA against PROQ, showing that farmers with lower scores in this

factor were more interested in expanding the business. They preferred to ensure a satisfactory income (not maximum) and they were less interested in producing the highest quality milk (*Expansionists, Income-ensurers, Less-quality-seeker*)[*Intensivists, Non-income-ensurers, Quality-seekers*]. In summary it could be said that FE1 represented the investment/saving dimension, FE2 represented the entrepreneurial-yeoman dimension while FE3 represented the expansionist/intensivist one.

Personal factors

FP1 was positively related to REDR and ENVI showing that those farmers with low scores in this factor were risk averse and tended to be more attached to producing environmentally friendly (*Risk-averse, Environmentalists*)[*Risk-takers, Non-environmentalists*]. FP2 was positively related to REDW and negatively to RECO showing that dedicated farmers wanted to be considered good farmers as recognition for their work (*Recognised-hard-workers*)[*Humble-Work-minimisators*]. However it should be said that the majority of farmers ranked RECO very low. Finally FP3 was positively correlated to TIMO and negatively to INNO demonstrating that more dedicated farmers tended to be more innovative (*Dedicated, innovative*) [*Non-dedicated, traditional*]. There is an apparent contradiction with the previous section in which dedicated farmers were less interested in INNO. However two facts should be taken into account. Firstly, it was demonstrated that it was not an effect of dedication *per se* but an effect of its correlated variable of educational level. On the other hand, dedication, as a farmers' characteristic, came from the actual number of hours that the farmers dedicate to farming, while TIMO is a measurement of the desire of having time for other activities. In fact these two variables were not correlated (Table 4.3). Therefore this result was a natural outcome from the hierarchies of objectives showing that those farmers whose desire was to be dedicated to farming (not necessarily dedicated farmers) wanted to be innovative as well. There was not an straightforward explanation for this relationship.

Familiar factors

Because only three familiar objectives were considered in the list of statements, each factor represented each one of the original familiar objectives. Factors were calculated in order to standardise the variables. Farmers with low scores in FF1 were identified to LSMA (*Conformists*)[*Non-conformist*]. Farmers with low scores in FF2 were interested in INHE (*Pro-inheritance*)[*Non-pro-inheritance*] and farmers with low FF3 wanted to improve their standard of living (LSIN) (*Pro-standard-of- living-improvement*)[*Non-pro-standard-of-living-improvement*].

General factors

Table 4.6 shows the rotated factor patterns for all factors together. FG1 was a contrast between FF1 and FP2 showing that those farmers identified with the profile *Conformists* were identified with being *Recognised-hard-workers*. Factor FG2 demonstrated that *Pro-standard-of-living-improvement* farmers were less identified with being *Investors* and more identified with being *Savers* showing the compromise between the farm's investments and the use of the economic resources for the family welfare. FG3 showed that the *Non-dedicated-traditional* farmers were not attached with re-investing in the farm and that they preferred to save money for retirement.

Table 4.6. Rotated factor patterns for all objectives, their eigenvalues and determination coefficients.

Original Factors	General Factors				
	FG1	FG2	FG3	FG4	FG5
FE1	-0.16437	-0.56237	-0.62262	0.02034	0.08004
FE2	-0.09280	-0.00555	0.19146	0.18103	0.76837
FE3	0.18245	-0.11728	-0.08838	0.74299	0.07218
FP1	0.26518	-0.28655	-0.06295	-0.69372	0.14202
FP2	0.78820	-0.04492	-0.00939	0.22937	0.00901
FP3	-0.04488	-0.17464	0.85795	-0.03600	0.02859
FF1	-0.78971	-0.07796	-0.02958	0.22569	0.02675
FF2	-0.08731	0.02402	0.22842	0.24539	-0.73294
FF3	-0.01419	0.90026	-0.13151	0.05315	0.00686
Eigenvalue	1.5107	1.4137	1.2093	1.0944	1.0656
Difference	0.0970	0.2044	0.1149	0.0288	0.1588
Proportion	0.1679	0.1571	0.1344	0.1216	0.1184
Cumulative	0.1679	0.3249	0.4593	0.5809	0.6993

This result demonstrates that the uses of innovations could be related to desire of re-investments in the farm against the desire of saving money for retirement. FG4 shows that *Expansionists, Income-ensurers, Non-quality-seeker* tended to be *Risk-takers, Non-environmentalists*. Finally FG5 gave evidence that those farmers mostly identified to maximisation of incomes and revenue were less interested in saving money for the education of their children or to inherence and therefore that they disassociate the farm as an economic business and the objectives related to the family.

4.3.4 Clustering farmers according to their objectives

The Ward clustering method demonstrated to be the most efficient one when CCC, PsF and PsT predicted the best number of clusters. This method explained more variation (r^2) with fewer clusters and produced the best graphical division of farms in the three-dimensional factor space (Economic clusters in figure 4.3). According to these statistics 6, 7, 7 and 10 were the best number of groups for economic, personal, familiar and overall objectives (Table 7). Figure 2 shows the dispersion of farmers in the 3-dimensional space by each group of objectives.

Table 4.7. Clustering statistics for selection of the best number of clusters

Number of Clusters	R^2	CCC	PsF	Ps t^2
Economic				
9	0.77185	-2.6508	34.3	7.5
8	0.74803	-2.6643	34.8	11.9
7	0.71161	-3.1062	34.1	20.9
6	0.67120	-3.3288	34.3	14.9
5	0.60208	-4.3857	32.2	22.5
4	0.50192	-5.9194	28.9	23.4
3	0.39615	-2.9824	28.5	24.4
2	0.20917	-2.4858	23.3	26.7
Personal				
9	0.76390	-3.1638	32.8	13.7
8	0.73427	-3.4851	32.4	13.7
7	0.69542	-3.9834	31.6	18.4
6	0.63701	-5.0035	29.5	12.7
5	0.57059	-5.7710	28.2	16.3
4	0.48978	-6.4072	27.5	30.8
3	0.38647	-3.3568	27.4	18.3
2	0.20276	-2.7483	22.4	26.2
Familiar				
9	0.77592	-2.3819	35.1	8.1
8	0.75358	-2.3204	35.8	8.7
7	0.72318	-2.4482	36.1	10.6
6	0.65788	-4.0012	32.3	17.0
5	0.59053	-4.9058	30.6	30.1
4	0.52298	-5.0439	31.4	18.6
3	0.41505	-2.2341	30.9	18.7
2	0.23414	-1.4426	26.9	33.6
1	0.00000	0.0000	.	26.9
General				
11	0.6215	-5.143	13.0	5.2
10	0.5953	-5.403	13.1	8.0
9	0.5631	-5.854	13.0	8.1
8	0.5295	-6.195	13.2	5.6
7	0.4843	-6.951	13.0	8.0
6	0.4369	-7.542	13.0	9.9
5	0.3750	-6.353	12.7	7.5
4	0.3066	-5.117	12.7	9.2
3	0.2380	-3.306	13.6	13.4
2	0.1212	-3.178	12.1	14.1

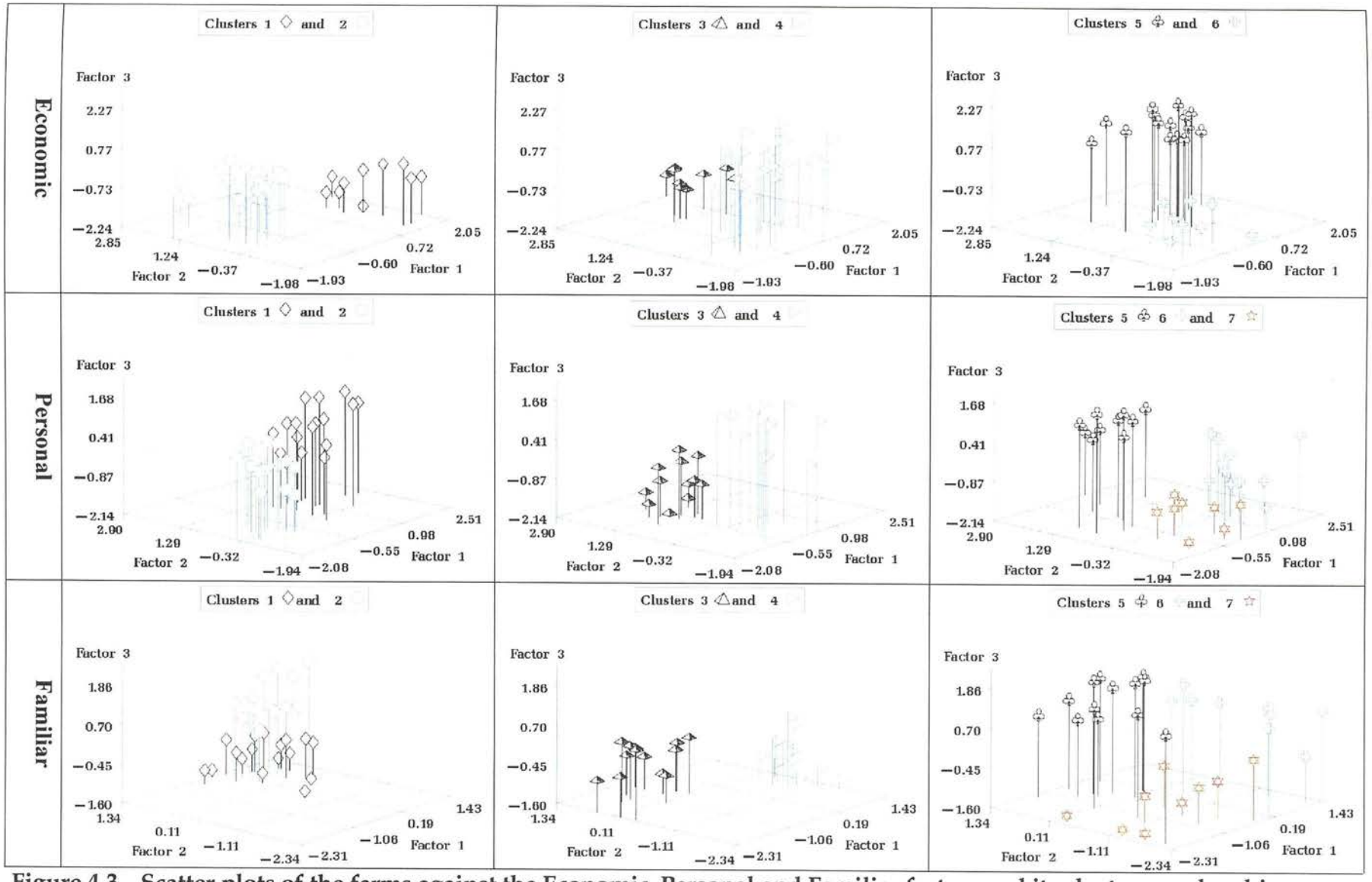

Figure 4.3. Scatter plots of the farms against the Economic, Personal and Familiar factors and its cluster membership

Economic profiles

Figure 4.4 shows graphically the means and confidence limits of the economic factor scores by each economic cluster as well as the frequencies and percentages of farmers in each group. These figure allowed the interpretation of each cluster and assign the traits of each group and define the respective profiles in Table 4.8.

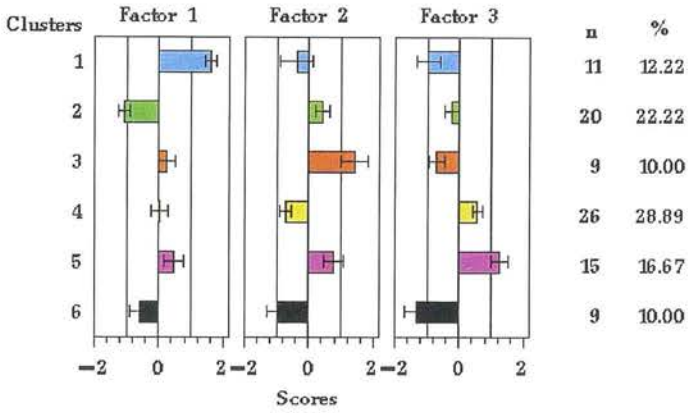

Figure 4.4. Means and confidence limits of the economic factors scores by clusters and the frequency of farmers in each group

Table 4.8. Cluster traits according to the affinity or oppositeness to the economic objective factors and the respective profile label

Cluster	Traits	Profiles
1	*Savers, Maximisators-entrepreneurs, Income-ensurers, Less-Quality seekers*	Ep1
2	*Investors, Expansionists, Income-ensurers, Quality-seekers*	Ep2
3	*Non-maximisators, Pro-family, Expansionists, Income-ensurers*	Ep3
4	*Maximizators-entrepreneurs, Intensivists,, Quality-seekers*	Ep4
5	*Non-maximisators, Pro-family, Intensivists, Non-income-ensurers, Quality seekers*	Ep5
6	*Investors, Mazimisators-entrepreneurs, Expansionists, Income-ensurers*	Ep6

From this figure and table it could be seen that *Quality-seekers* (67.7%), *Income-ensurers* (54.4%), *Maximisators* (51.1%), *Intensivists* (45.6%) and *Investors* (32.2%) were the most common economic traits in the population. This demonstrated that PROQ was the only economic objective in which there was a consensus among the

farmers. Because this objective is directly related to the incomes of the farms, it could be said that this objective is considered a means of obtaining other economic goals.

Income-ensurers trait was present in very different combinations with other traits, even in cases where maximising of incomes and revenue were neutral (Ep2) or important goals (Ep1 and Ep6), ensuring a satisfactory income was highly desired. It seems to be a desire of obtaining a satisfactory income in the worse of the cases and then try to maximise incomes and revenue.

Although *Maximisators* were very frequent in the population, that showed the business orientation of the majority of Costa Rican dairy farmers, 26.7% of farmers were opposed to this objective and attached to saving money for children education, demonstrating that monetary maximisation was not a consensus among farmers.

There was polarity among the farmers in term of expansion or stability of the size of the business, 46% of farmers were identified with the *Intensivists* trait while the 42.2% to the *Expansionist* one. As mentioned before, the marketing condition in the country could be making the farmers change this objective in favour of expansion of the size.

A considerable proportion of farmers were identified with re-investing in the farm while a small proportion of them were attached to saving money for retirement. This result could respond to the age of the farmer, where older farmers will be more interested in their retirement and younger farmers on re-investments in the farm.

In terms of clusters, it could be said that the 6 categories of farmers represented well differentiated farmers' economic profiles. Ep3 and Ep5 represented the non-business-oriented farmers with more interests in the family's welfare since they were the farmers who ranked EDUC higher. The former group was attached to expansion of their business while the later are *Intensivists*. Since neither maximisation of incomes/revenue nor obtaining satisfactory incomes were ranked high in Ep5, this profile could be considered the less economic-oriented of all the population.

Ep2 represented a group of farmers more interested in re-investing in the farm, expanding the business, obtaining a satisfactory incomes producing the best quality of milk. This combination of traits could be related to farms in earlier stages of

development in which maintaining the activity by assuring the cash flow is the most important objective and not necessarily obtaining the maximum income.

Regarding to *Maximisators,* Ep4 represented the most business-oriented group of farmers since they were interested in obtaining the maximum incomes/revenue in the same scale of business and producing the best quality of milk. They were not even interested in a satisfactory incomes but the maximum. Ep1 and Ep6 were also *Income-ensurers* showing that the majority of *Maximizators* preferred to ensure a satisfactory income as well, probably as a step towards maximisation. Ep1 was the only group where farmers were attached to saving money for their retirement. This profile could be related to older farmers.

Personal profiles

Figure 4.5 shows the Lsm of the Personal objective by each cluster and the frequencies of farms in each group. Table 4.9 shows the traits assigned to each group.

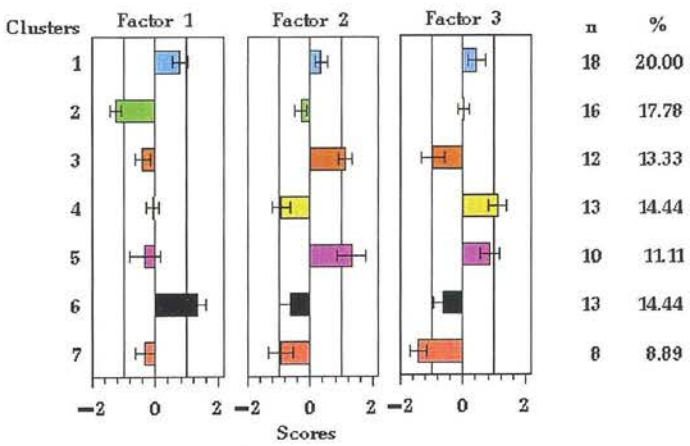

Figure 4.5. Means and confidence limits of the personal factors scores by clusters and the frequency of farmers in each group

Table 4.9. Cluster traits according to the affinity or oppositeness to the personal objective factors and the respective profile label

Cluster	Traits	Labels
1	*Risk-takers, Dedicated innovative*	Pp1
2	*Risk averse, Environmentalists, Hard-worker, Humble*	Pp2
3	*Environmentalists, Recognised-Hard-worker, Non-dedicated, Traditional*	Pp3
4	*Risk-averse, Environmentalists, Humble-Work-minimisators, dedicated innovative*	Pp4
5	*Environmentalists, Recognised-Hard-worker, Dedicated- innovative*	Pp5
6	*Risk-takers, Non-environmentalists, Work minimisators, Traditional*	Pp6
7	*Environmentalists, Humble-Work-minimisators, Non-dedicated traditional*	Pp7

From there it could be seen that the most common personal traits were: Environmentalists (65.5%), Dedicated-innovative (45.5%), Hard-workers (42.2%), Humble (41.1%) and Risk-takers (34.4%). This evidence showed that in general Costa Rican dairy farmers were strongly attached to the idea of producing in harmony with natural resources. In fact this was the only personal objective in which there was consensus (14.4% of farmers were opposed to this objective). However the fact that they considered themselves as Environmentalists does not means their farming approach is also environmentally friendly. In general Costa Rican Farmers were attached to working hard, being dedicated to farming, without any recognition from other farmers and with being risk-takers. However the opposite traits i.e. Non-dedicated (36.6%), Work-minimisators (37.7%), Recognised (24.4%) and Risk-averse (32.2%) were quite similar in importance than their counterparts. This shows the polarity of farmers respect to these objectives and that having a good life, gaining social recognition as a farmer and reducing risks were still important objectives for Costa Rican dairy farmers. The latter goal could be related to sells of the replacement heifers and cows in which, those recognised farmers have comparative advantages regarding to pricing and demand of animals.

Pp1 and Pp6 represented risk-taker farmers. However the Pp6 tended to be reduce work and time in farming activities. They were probably farmers with other economic activities than the farm and therefore their dependence from farming could

be smaller so taking risks is less dangerous for them. This profile was the only one with a clear oppositeness to producing in harmony to the environment. Pp1, on the other hand, did take more risks but probably related to new practices since they prefer to be dedicated to the farm and use technological innovations. Pp2 and Pp4 were risk averse farmers, the difference between them is that the former group was related to working hard in the farm whilst the later was related to reduce it but being dedicated and innovative, probably as a way of reducing physical work. Pp3 and Pp5 were the only groups that tended to be attached to gaining recognition as good farmers probably as a product of their hard work. However they were opposite in terms of dedication and innovations. There seems to be a contradiction in the Pp3 since they wanted to be recognised as hard workers but they did not want to dedicated much time to the farm nor use much innovation. That means that its recognition could be related to efficient hard working in the farm in order to have more time for other activities. Finally, the desire of recognition in Pp5 could be related to being recognised as dedicated and innovative farmers.

Familiar profiles

Figure 4.6 and Table 4.9 show the Lsm and the traits assigned to each group of farmers from the point of view of Familiar objectives.

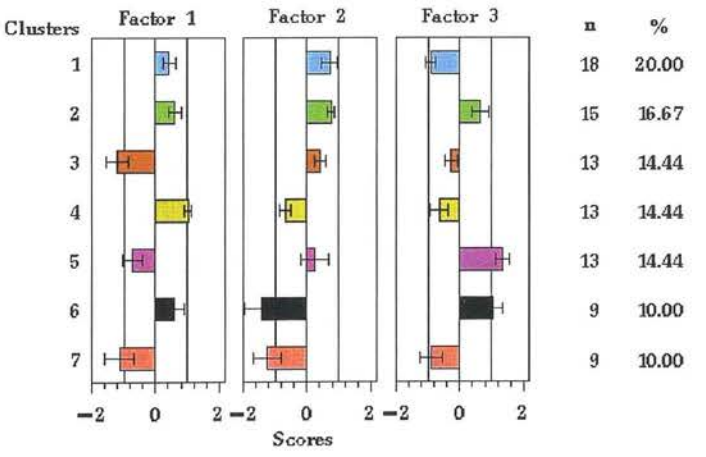

Figure 4.6. Means and confidence limits of the personal factors scores by clusters and the frequency of farmers in each group

Table 4.10. Cluster traits according to the affinity or oppositeness to the familiar objective factors and the respective profile label

Cluster	Traits	Profiles
1	*Non conformists, Non-pro-inheritance, Pro-live-standard improvement*	Fp1
2	*Non conformists, Non-pro-inheritance, Non-pro-live-standard improvement*	Fp2
3	*Conformists, Non-pro-inheritance*	Fp3
4	*Non-conformists, Pro-live-standard improvement*	Fp4
5	*Non-pro-inheritance, Non-pro-live-standard improvement*	Fp5
6	*Non-conformists, Pro-inheritance, Non-pro-live-standard improvement*	Fp6
7	*Conformists, Pro-inheritance, Pro-live-standard improvement*	Fp7

Although the majority of Costa Rican farmers were Non-conformists (61.1%) [24.4% Conformists] only 44.4% are attached to the Pro-standard-of living-improvement trait showing that a big proportion of the farmers were neutral (14.4%) or not interested in improving their standard of living (41.4%). This result could be explained by the possibility that their current standard of living was satisfactory for them or that familiar objectives were ranked very low in comparison with the economic and personal. Inheritance issues seem not to be important since 65% of farmers were opposed to it. Since this objective is positively related to the age of the farmer, it could be said that it responds to the small proportion of farmers in old ages in the studied population.

Fp1 and Fp4 represent those farmers who were not satisfied with their standard of living but want to improve it. The only difference between these two profiles is that the former was strongly against inheritance of the farm, while the latter was neutral in this matter. Fp6 and Fp7 were the cluster of farmers interested in past the farm to the next generation, however these groups were opposed in term of their point of view of the standard of living of their families. Fp2 and Fp5 could be considered the less familiar oriented groups of farmers.

General profiles

The final cluster analysis showed that 10 groups of farmers were necessary in order to explain more that 60% of the original variation in the data. This result demonstrated the variability of arrangements of the objectives in general. There was also heterogeneity with respect to the size of the groups. The five biggest groups represented nearly 70% of population, the remaining groups only accounted for 30% of it, some of them being very small (8 and 9) showing some very unique combinations of goals. Table 4.11 shows the ranking of objectives by each general cluster derived from the Lsm and confidence limits in Appendix 3.

The biggest group (GP6) (20%) represented those farmers attached to economic goals PROQ, MAXI, MAXR and INC combined with the personal objective ENVI. This shows that a big proportion of Costa Rican dairy farmers have the desire of maximising monetary incomes through the best quality of milk and at the same time producing in harmony to the environment. They wanted to be dedicated hard workers and they were not interested in retirement or in passing the farm to the next generation.

Table 4.11. Ranking of objectives according to the least square means of each objective by each overall cluster

Clusters																			
Gp1		**Gp2**		**Gp3**		**Gp4**		**Gp5**		**Gp6**		**Gp7**		**Gp8**		**Gp9**		**Gp10**	
Maxr	2.9	Proq	3.9	Inc	3.8	Proq	1	Maxi	3.2	Proq	2.4	Lsin	1.6	Proq	4	Inhe	2.3	Proq	4.9
Lsin	4.1	Envi	4.9	Expa	4.4	Inve	4.2	Proq	3.2	Envi	4.8	Proq	5.9	Educ	5.5	Expa	2.5	Maxi	5
Maxi	4.2	Lsin	5.2	Maxi	5	Expa	4.2	Inc	3.7	Maxi	5.1	Monr	6.1	Inc	6.3	Proq	5.5	Envi	5.1
Monr	6.2	Redr	5.9	Maxr	5.8	Maxr	6.5	Maxr	4	Maxr	5.4	Inc	6.4	Envi	6.3	Inc	6.3	Lsma	5.9
Proq	6.4	Educ	6.6	Proq	5.9	Innov	6.5	Innov	5.3	Inc	6.7	Expa	6.7	Monr	6.8	Inve	6.8	Educ	7.1
Inc	7	Innov	7	Inve	6.1	Inc	7.2	Lsin	6	Inve	7.2	Inhe	6.9	Maxi	6.8	Innov	6.8	Inhe	7.4
Envi	8.1	Expa	7.4	Redr	8.5	Lsma	7.3	Inve	8.7	Redr	7.5	Maxr	7.3	Timo	7	Timo	8.3	Inc	8.4
Expa	8.3	Inc	8.5	Innov	8.8	Envi	8.3	Redr	8.8	Expa	9.3	Educ	7.4	Maxr	7.3	Redw	8.5	Maxr	8.6
Educ	9	Maxi	8.6	Redw	10	Reco	9.8	Monr	9.8	Educ	9.7	Lsma	8	Expa	7.3	Maxr	9.5	Lsin	8.7
Timo	9.2	Inve	8.8	Lsin	10.1	Redr	11	Envi	10	Lsma	9.9	Maxi	8.1	Redr	7.8	Redr	9.8	Reco	8.9
Inhe	9.8	Maxr	9.2	Monr	10.9	Educ	11.2	Educ	10.7	Lsin	10.4	Innov	9.7	Inhe	9	Educ	10.3	Timo	9.1
Redw	10	Monr	9.9	Timo	10.9	Redw	11.2	Expa	10.8	Innov	10.9	Inve	10	Redw	10.5	Envi	10.5	Monr	10.9
Innov	10.9	Redw	11.7	Envi	11.3	Monr	11.5	Redw	11.3	Timo	11.3	Redw	12.1	Inve	12.5	Lsma	11.3	Inve	11.3
Redr	12.1	Inhe	12.1	Inhe	11.6	Maxi	12.2	Lsma	12.7	Monr	11.8	Envi	13.3	Lsma	12.5	Maxi	11.8	Expa	11.6
Inve	13.7	Timo	12.6	Educ	11.8	Lsin	12.2	Timo	12.8	Redw	11.8	Redr	13.9	Reco	14.5	Lsin	12.8	Redr	12.3
Reco	14.6	Lsma	14.3	Lsma	11.8	Inhe	13.2	Inhe	15.5	Reco	13.8	Reco	14.6	Lsin	14.5	Monr	14	Innov	13.3
Lsma	14.7	Reco	16.4	Reco	15.9	Timo	15.3	Reco	16.5	Inhe	14.9	Timo	15	Innov	14.8	Reco	16.3	Redw	14.3
n	**9**		**14**		**15**		**6**		**6**		**18**		**7**		**4**		**4**		**7**
%	**10.0**		**15.6**		**16.7**		**6.7**		**6.7**		**20.0**		**7.8**		**4.4**		**4.4**		**7.8**

GP3 (16.7%) shared basically the same goals than the previous group except that this group was less interested in the environment and pays less attention to the milk quality. This group seems to be less intensivists since they were more interested in expanding the size of the business before maximising incomes. These two groups represented the most entrepreneurial orientation since familiar goals occupied a medium to low importance for these farmers.

GP2 (15.6%) were still interested in milk quality but they were not maximisators. On the contrary they were more attached to personal goals such as ENVI and REDR, the familiar goal LSIN and the economic goal EDUC. They were dedicated, hard-worker and they were not interested in passing the farm to next generation. They represented the less entrepreneurial and more familiar farming orientation.

GP1 (10%) was composed by farmers interested in maximising incomes and revenue, probably as a way of obtaining other goals like improving the familiar standard of living and saving money for retirement. They pay less attention to milk quality, reducing risks, being innovative, reinvestments and maintaining their standard of living. They represented those farmers with a balance between economic maximisation and familiar goals with a strong desire of improving the familiar standard of living rather that in maintaining it.

Farmers belonging to the GP10 (7.8%) were milk quality seekers, income maximisators, environmentalists. They were more interested in LSMA rather that LSIN showing that they were satisfied with their standard of living. They consider saving money for education and passing the farm to the next generation important goals. They were opposed to re-investment, expand, reducing risks, being innovative, and reducing work. Along with group 1 they had a balance between economic and familiar goals. This group is probably related to farmers in the final stage of their careers.

GP7 (7.8%) was another non-maximising and more pro-familiar group in which the most important goal was LSIN following by PROQ, MONR, INC. They tended to be more identified to INHER and they were dedicated hard-workers and risk-takers.

GP4 (6.7%) seem to be those farmers in earlier stages of development and with a very entrepreneurial orientation since PROQ, INVE, EXPA and INNO were highly

desired. In this group there was a clear differentiation between MAXR and MAXI, the former being much more important for them showing a revenue oriented profile.

Group 5 (6.7%) was a another economic oriented group sharing basically the same goals than GP6 except that this group was less attached with producing in harmony with the environment and they were more innovative and want to improve their standard of living.

Group 9 (4.4%) was the only group in which INHE was located within the first five goals. They were interested in EXPA probably as an attempt to inherit as much as possible to the next generation. In economic terms, they try to ensure high milk quality and obtain a satisfactory income. Although they want to inherit the farm, they were interested in INVE showing that they want to inherit a farm in a development process. They were not identified with familiar life standard goals nor economic maximising.

Finally group 8 (4.4%) was linked to PROQ EDUC, INC, ENVI and MONR showing that it was an intrinsically economic oriented group but oriented towards the familiar welfare with interests in producing in harmony to the environment. They seem to be satisfied with their familiar standard of living since LSMA and LSIN were ranked low. This was one of the less innovative groups.

In summary it could be said that groups 3, 4, 5, 6 were maximizators entrepreneurs, groups 1 and 10 were farmers with a balance between economic maximising and familiar objectives while groups 2, 7, 8 and 9 were identified with familiar goals. In general terms 50.1% of Costa Rican farmers were maximizator entrepreneurs, 32.2% were familiar-oriented and 17.8% were maximisator-pro-family. These results demonstrate that economic maximisation in the preponderant farming orientation by Costa Rican dairy farmers. However familiar objectives are still very important for nearly half of them.

4.4 Concluding remarks

There are several relationships between farms'/farmers' characteristics and objectives priorities, being the age, educational level and the size of the farm the characteristics that have the biggest impact in shaping the objective hierarchies. However the low production power showed by the Canonical Correlation analyses is

evidence that other variables are affecting and defining the objective hierarchies of the Costa Rican farmers. Nevertheless, it is important to point that if less objectives were tested, the prediction power would be higher, since the overall variation would be smaller. In any case the finding showed in this chapter could lead to more research in order to increase the prediction power of the goals.

There are important correlations among different objectives that make it possible to build factors that represent these relationships, thus reducing the problem.

Well-defined groups of farmers exist from the economic, personal and familiar points of view. It is also concluded that there is a big heterogeneity of goals among farmers and that many groups are needed in order to represent this variability.

Costa Rican dairy farmers have a mixture of goal orientations, from the very entrepreneurial economic maximisation to the very familiar orientations, being the former orientation the most frequent. However mixtures of economic and familiar goals and the very familiar profiles are found in approximately a half of the population showing that other non-economic goals also driving the farmers.

For the purposes of the thesis, the motivation component of the decision-process has been satisfactorily characterised by 3 profiles, representing 3 different dimensions of the personality on motives of the farmer i.e. his/her economic orientation, his/her personal orientation and his/her familiar orientation. The fourth dimension provides a more generalised representation of the farmer orientation taking into account all the objectives together.

With these profiles already defined, the next step is look at relationships, if any, between the profiles and the way the farmers manage the farms' resources, the use of technologies and on the level of success of the farm in terms of performance. These relationships are analysed in depth in the chapter 7.

Although the Rokeach's technique has been extensively used in social sciences (Foddy 1993) and in agriculture behavioural research (Perkin and Nehman, 1994) and farmers had not problems in ranking the 17 objectives, this amount of items could contribute to the big heterogeneity in the arrangements of goals. Two problems were detected: farmer were not able to drop any of the items when they considered them non relevant and, two or more items should be ranked differently even if they were equally important for them. Therefore, future research should take into account

less items to be ranked, with the possibility of dropping those non-relevant items and allowing items with equally ranked. Nevertheless, because this research was an exploratory one, unless from the point of view of goal hierarchies among the Costa Rican farmers, this technique showed to be successful in eliciting the farmer's attitudes towards objectives.

Chapter 5 Who makes farming decisions? *

Abstract

Decision-making approaches, the factors affecting them, the role of the decision-making units and the actors involved in farming decisions were studied in 91 Costa Rican farmers using a classification procedure. Farmers were asked to classify 18 farming decisions (systematically selected from a pool of 100) into a series of categories of decision-making units (Alone, Family, Shared, Delegated) and actors (person/people involved). Frequency tables and multivariate analyses were used to analyse the data. A canonical correlation analysis (CCA) was performed to find out simple and canonical correlations between farmers'/farms' characteristics and the decision-making approaches. Factor analysis (FA) combined with a Cluster (CLA) were used in order to: 1- define groups of farmers with similar decision-making approaches, 2-define groups of decisions made by similar decision-making units. Logistic Regression was used to study the influence of the intrinsic characteristics of the decisions (Traits) and the decision-making units involved. A Multiple Correspondence Analysis (MCA) was used to graphically represent the relationships between shared and delegated decisions and the actors involved.

The CCA showed that the level of dedication to farming, the educational level and the size of the farm were the characteristics more strongly influencing the decision-making approaches. Monopolisation by one decision-maker was the most frequent decision-making approach in the population since half of decisions were made by the farmer alone. However other approaches in which other decision-making units, mostly the Family, have an important role were also frequently found in the population. FA and CLA found very well defined groups of decisions in terms of decision-making units involved. The Logistic regression found that the traits of the farming decisions influenced the level of involvement of the different decision-making units. Operational decisions tended to be more delegated to farm staff and family members, while technical decisions were mostly shared mainly with technical advisors and family members.

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* based on Solano, C., Herrero, M., León, H. and Pérez, E. (2000) Who makes farming decisions? A study of Costa Rican dairy farmers. Agricultural Systems (submitted)

5.1 Introduction

In chapter 2, four lines of thinking were identified respect to the question "who actually makes farming decisions?". These four lines acknowledge: 1-the unity of authority, 2- the influence of other peoples but one decision-maker, 3- the family as the decision-making unit, and 4- the existence on other decision-making units different than the farmer and the family respectively

From the literature review in that chapter, it was concluded that several factors are defining the decision-making units and that several units can either co-exists or become preponderant as a result of the very specific conditions of each study. What was clear is that more evidence, especially from developing countries, was necessary to understand this phenomenon and by this way go towards a better understanding of the decision-making process and therefore agricultural development through 'tailor made' extension activities.

The aim of this chapter is to show some empirical evidence of the dynamics of decision-making and the involvement of different actors in this process under a wide variety of farmers'/farm's conditions and decision-types. A definition of the decision-making approaches in the population is also made. These profiles are used in chapter 7 to quantified their impact on farm management and performance.

5.2 Materials and Methods

5.2.1 Classification procedure

A list of 18 decisions was systematically selected from a pool of 100 farming decisions often taken by farmers. The pool was selected from the authors' own experience at farm level as both, managers and technical advisors. The authors scored the 100 decisions with values from 1 to 5 for 7 different traits i.e. Frequency (Frq) representing how often the decisions are usually taken; Term (Ter) is the term in which the decision still have effects; Investment (Inv) which is the capital required for implementing the decision; Effect (Efp) is the potential effect on milk production at herd level, Risk (Ris) is the level of risk involved in the decisions, Information (Inf) is the level of information required to make the decisions, Reversibility (Rev)

which is the possibility of reversing the outcomes of the decision in case of an adverse effect. A Factor Analysis combined with a Cluster analysis were used to group similar decisions. From nine groups formed, two decisions were selected from each one. By this way the selected sub-set of decision were intrinsically very different. Table 5.1 shows the final list of decisions and their traits values.

Table 5.1. Selected decisions and their traits

Decision	Ter	Efp	Inv	Inf	Freq	Ris	Rev
Replacement selection	5	5	1	4	4	5	5
When to deworm	3	1	1	2	3	2	5
Activities designation	1	1	1	5	1	3	1
Herd grouping for feeding	3	5	2	5	3	3	2
Amount of concentrate/cow	3	5	5	5	2	5	3
When to inseminate a cow	3	2	1	3	1	2	4
To use a credit	5	1	5	5	5	5	3
Type of nitrogen fertiliser	2	1	1	2	2	1	1
Change of land use	5	1	5	3	4	3	3
To introducing a new pasture species	5	3	3	5	5	5	5
When to mate a heifer for the first time	5	1	1	1	2	2	4
Labour recruitment	1	1	1	1	2	1	1
Which paddocks to graze and order	2	5	1	3	3	4	2
When to run a California Mastitis Test	2	2	1	1	2	1	4
Type and amount of by-products/cow	4	5	5	5	4	5	3
Machinery purchase	5	1	5	4	5	4	3
Amount of milk per calf	2	1	3	2	1	1	2
How many replacements to raise	5	3	4	3	4	2	1

Once the decisions were selected they were introduced into Edical Software (see chapter 3) and each one was written onto a label. Farmers were instructed to classified the decisions into 5 categories of decision-making units (CDMUs): Alone, Family, Shared (when it was a conjoint decision), Delegated, or Not apply (when the decision did not apply to the farm). If the categories Shared or Delegated were chosen, farmers were asked to choose the person/people involved. They were selected from a list of people currently working in the farm. This list had been previously completed with details of age, educational level (none, primary, secondary, technical, university) type of manpower (familiar-father, familiar-spouse, familiar-children, familiar-other; external; advisors-veterinarian, advisor-animal

science, advisor-agronomist, advisor-managerial) and working time on farming (hours/week). The classification procedure is shown in Figure 5.1.

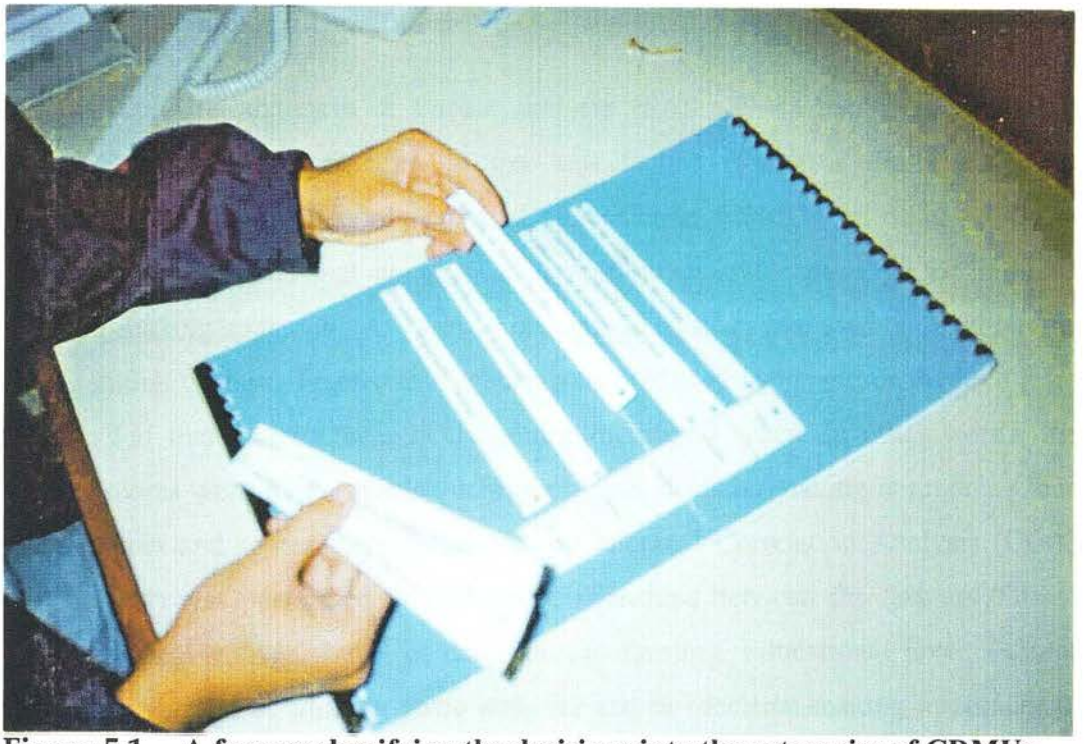

Figure 5.1. A farmer classifying the decisions into the categories of CDMUs

5.2.2 Database edition

Two databases were constructed to analyse the information. The first one was designed to count the frequency of decisions that each farmer classified into each CDMU. Therefore the analyses of this database considered the farmer as the analysis unit for studying the population in terms of decision-making approaches, defining profiles, and for studying their relationships with the farmers'/farms' characteristics. The second database was designed to consider each decision as the analysis units. This database was a two-way frequency table that counted the frequency that each decision was classified into each CDMU. With this database, relationships between the intrinsic characteristics of the decisions (traits) and the CDMU could be made.

5.2.3 Statistical analyses

5.2.4 Relationships between farmers'/farms' characteristics and the decision-making approaches

Using the first database, a Factor analysis (SAS, 1994) using the Principal Components method was used to find out factors (Fafs) or dimensions that represented the level of involvement of the different CDMUs. In other words to define the dimensions that construct the multidimensional space of the farmers' decision-making approach. A Varimax orthogonal rotation was used to facilitate the interpretation of these dimensions. The analysis produced factor scores for each farm in each Faf that located them in the multidimensional space. In other words, the farmer' scores were new variables defining his/her decision-making approach. Once these factors and scores were calculated, a Canonical Correlation Analysis (CCA) (SAS, 1994) was performed to find out relationships between the farmers'/farms' characteristics i.e. Age, Level of dedication to farming, Educational level, Pasture Area and Number of milking cows with the scores (decision-making approaches). This analysis produced both simple and canonical correlation matrixes.

5.2.5 Defining the decision-making approaches in the population

Using the Fafs scores, a Cluster Analysis (CLU) (SAS, 1994) was used to define groups of farmers with similar decision-making approaches and for defining population profiles. The Ward clustering method was used to calculate the distances. The final number of groups was decided by looking for a consensus of four statistics: high Determination coefficient (r^2), a peak in the Cubic Clustering Criterion (CCC) and Pseudo F statistic (PsF) and a small value of Pseudo T statistic (PsT) (SAS, 1994).

5.2.6 Relationships between decisions and the decision-making units

The first step of this section was to calculate the relative importance of each decision-making unit in the population. It was obtained by calculating the percentage of the decisions made by each CDMU.

The second step was to define the relationships between individual decisions and the CDMUs involved. Using the second database, another Factor Analysis was used to produce factors (Fad) or dimensions representing the multidimensional of the level of involvement of the decision-making units. The analysis produced factor scores for each decision in each factor. These scores located each one in the multidimensional space, so depending on their geometric location, relation with different decision-making units could be uncover. These factor scores were introduced into a second CLU analysis in order to define groups of decisions made by the same decision-making units.

A Logistic Regression Analysis (SAS, 1994) was used to study the relationships between the intrinsic characteristics of the decisions (traits) and the level of involvement of the CDMUs. A series of univariate models calculated the Odds ratios that estimated the probabilities of each decision being made by each CDMU according to its intrinsic characteristics (traits) (it is univariate in the sense that each trait was evaluated separately). Four binomial (1,0) response variables were computed (dec1-dec4) where dec1, dec2, dec3 and dec4 represented the Family, Alone, Shared and Delegated decision-making units. Each of these variables took a value of 1 if a decision where made by this unit while 0 otherwise. A binomial response variable was used instead to a multi-nomial for simplicity reasons and because the exploratory aim of the analysis. The explanatory variables were computed from the original score values of each traits used to select the decisions from the original pool. A series of dummy variables were calculated to compare the score values 2, 3, 4 and 5 against 1 (basal value) for each trait. Therefore, for example, the trait Information requirement was transformed into 4 dummy variables (Inf1, Inf2, Inf3 and Inf4). A model syntax example is:

$$dec1 = Inf1 + Inf2 + Inf3 + Inf4$$

where dec1 is the binomial variable accounting for the decisions made and not made in Family; Inf1 is a dummy explanatory variable representing Inf score value 2, Inf2 is the dummy variables representing the score value 3 and so on. In this way the regression estimated the probabilities (Odds ratios) and their significance (χ^2) of

decisions being made in family when they took different score values (from 2 to 5) of information requirement in comparison with the basal score value 1 (Intercept). Similar models were used for the rest of response variables and traits. In the traits Ter and Efp the score value 4 was missing. The traits Frequency, Reversibility and Risk were not taken into account due to their correlation with Investment, Term and Information respectively. In other words they represented the same dimension of the decisions.

5.2.7 Relationships between Shared and Delegated decisions and actors involved

When decisions belonged to the Alone or Family categories, the actors involved in making these decision were obvious (the farmer himself or the family members). However in the case of the Shared and Delegated categories, the actors were not apparent. In order the find-out the type of people involved in making these decisions, two separated Simple Correspondence Analysis (SCA) (SAS, 1994) were performed. This analysis finds low dimensional graphical representations of the association between row and columns of a contingency table (in this case between decisions and actors) (SAS, 1994). The categories of actors were defined according to the labour types where familiar-father, familiar-spouse, familiar-children, familiar-other were joint together in the same category (Family); farm staff (Farm staff); technical advisors-veterinarians (Veterinarian), technical advisors-animal science (AnimalSci) and technical advisors-agronomist (Agronomist). (No frequencies for technical advisors-managerial were found).

Figure 5.2 summarises the methodology used throughout the analysis of the data.

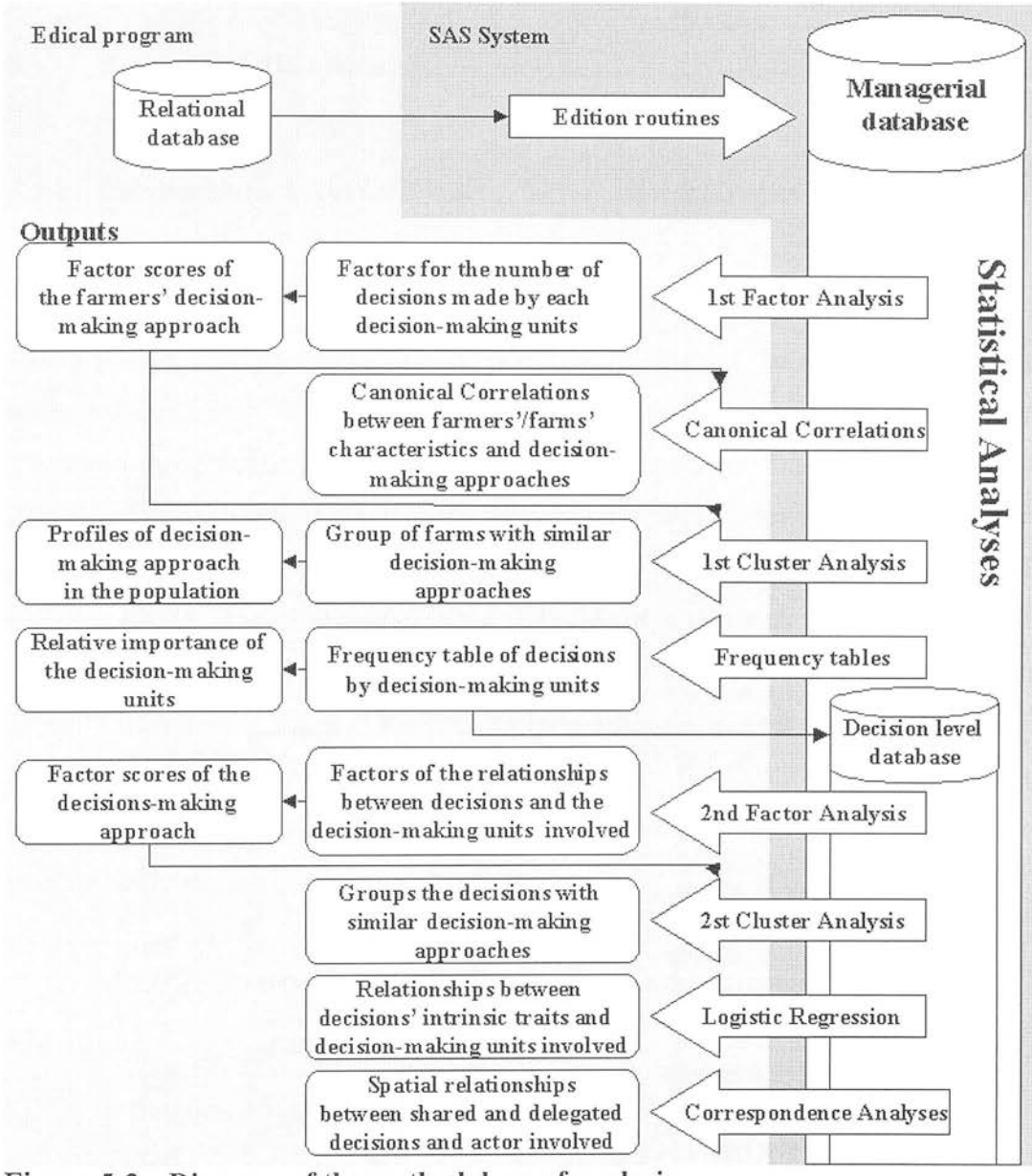

Figure 5.2. **Diagram of the methodology of analysis**

5.3 Results and discussion

5.3.1 Relationships between farmers'/farms' characteristics and the decision-making approaches

The FA found that 3 factors explained 98% of the original variance. Table 5.2 shows that Faf1 uncovered an inverse relationship between the number of decision made by the farmer himself and the number of decisions made by the family. Therefore those farmers with low scores in this dimension made more decisions Alone and few in family while those farmers with high scores made decisions the other way round. (therefore this factor was labelled as "Alone vs Family"). Faf2 represented the dimension towards sharing decisions, so farmers with high scores in this factor made more shared decisions while those in low score made more decisions alone ("Shared vs Alone"). The Faf3 represented a dimension towards delegation against decision made Alone ("Delegated vs Alone"). The location of each farmer in the three-dimensional space constructed by these factors represents their decision-making approach.

Table 5.2. Rotated Factors of the relationship among categories of decision-making approach (farmer level)

Decision-Making approaches	Factors		
	Faf1	Faf2	Faf3
Alone	-0.78119	-0.43643	-0.42540
Share	-0.03113	0.99570	0.03631
Delegate	-0.02574	0.03694	0.99602
Family	0.95466	-0.19769	-0.19035
Eigenvalue	1.6907	1.3454	0.9201
Proportion	0.4227	0.3363	0.2300
Cumulative	0.4227	0.7590	0.9890

The simple correlation matrix (Table 5.3) demonstrated that Dedication was inversely proportional to Faf3, therefore the less dedicated the farmer was the more decisions were delegate as a result of his/her absence. Educational level was correlated to the three factors of decision-making approach, showing that well

educated farmers tend to make less decisions in family and more decisions alone, shared and delegated. The Area of the farm was not correlated to any factor. However, the size of the herd increased the necessity of delegating decisions showing that it was the intensification level that influenced the decision-making approaches.

Table 5.3. Correlation matrix among farmers'/farms' characteristics and factors of decision-making approach

Variables	Distance	Age	Dedication	Education	Pasture Area	# Cows
Distance	1	0.233***	0.0647	0.022	0.293***	0.071
Age		1	-0.0791	-0.254**	0.213**	0.108
Dedication			1	-0.371***	-0.025	-0.154
Education				1	0.0574	0.352***
Pasture Area					1	0.483***
# Cows						1
Faf1	0.16560	0.03028	0.16803	-0.25894**	0.158	0.030
Faf2	-0.00044	-0.06462	0.14766	0.20907**	0.146	0.097
Faf3	0.04880	0.04037	-0.3184***	0.25936**	0.190	0.279***

* P<0.1, **P<0.05, ***P<0.01

The CCA found three medium significant canonical correlations. The interpretation of these analysis was based on the correlations between the original variables and their respective canonical variables (CCVs and FCVs in Table 5.4) and then interpreting the correlations between these two new canonical variables.

The first canonical correlation shows a relationship between education and dedication area with Faf1 and Faf3. This demonstrate that those farmer with higher education tend to dedicate less time to farming, probably because they have other economic activities (professionals). This combination of characteristics influenced against decisions made in family and in favour of decisions made alone and delegated. The lower involvement of the family and the higher delegation could respond to the absence of both the family and farmer, due to they probably live in cities because the other economic activities of the farmer.

The second canonical correlation was a relation between Dedication and Faf2 demonstrating that those dedicated farmers tended to share decisions probably due his/her presence in the farm and the closer relationships with other people like the farm staff.

Table 5.4. **Correlation matrix of farmers'/farms' characteristics and factors of decision-making approach with their respective canonical variables**

Canonical variables of Farmers'/farms' characteristics			
	CCV1	**CCV2**	**CCV3**
Distance	-0.1215	-0.1721	0.4923
Age	-0.0116	-0.2270	0.0374
Dedication	-0.6453	0.6814	0.2297
Pasture area	0.4953	-0.1750	0.5887
# Cow	0.2210	-0.0171	0.8741
Education	0.8913	0.2985	-0.0225
Canonical variables of Fafs			
	FCV1	**FCV2**	**FCV3**
Faf1	-0.5624	-0.2238	0.7960
Faf2	0.3002	0.8417	0.4488
Faf3	0.7705	-0.4913	0.4062
Correlation	0.4597	0.3568	0.3076
Pr>F	0.0021	0.0290	0.0764
PredP	0.0531	0.0141	0.0222

PredP is the variance of FCVs explained by CCVs (prediction power)

The third correlation showed a relationship between Pasture Area, Number of milking Cows with Faf1 and slightly Faf2 and Faf3 providing evidence that the dimension of the farm was positively correlated to the number decisions made in family. An explanation for this finds could lie on medium correlation between CCV3 and distance showing that the remoteness of the farm have an effect on the sizes of the farms and in the involvement of family as they probably live in the farm.

The fact that Pasture Area was not significant in the simple correlation matrix and was significant in the canonical correlation could be due to the Number of cows is a function of the Pasture Area. Therefore when they are taken into account together the Area becomes an important variable in defining the decision-making approach. Dedication was an important variable defining the first two canonical variables, showing this variable was important in shaping the decision-making approach regardless of the educational level of the farmers. The Age of the farmers was not a relevant variable shifting the decision-making approach. Although Errington (1986) found similar finding in terms of dedication and size of the farm and delegation, he found a negative relation with age, which do not agree with this results.

The variance explained by the three canonical variables only account for 8% (Table 5.4), demonstrating the low power of prediction of the decision-making approach through the studied farmers'/farms' characteristics.

5.3.2 Defining the decision-making approaches in the population

The best number of groups of farmers was obtained in n=4, n=5 and n=10 as demonstrated by the clustering statistics in Table 5.5. It can be seen that the CCC, PsF and R^2 increased as the number of cluster increased while the PsT statistic decreased in these points.

Table 5.5. Clustering statistics for selecting the best number of clusters of farmers according to their decision-making approach

Number of Clusters	R-Squared	Cubic Clustering Criterion	Pseudo F	Pseudo t^2
10	0.87080	33.0018	1219.1	201.9
9	0.85034	28.7106	1156.9	326.9
8	0.82414	23.9040	1091.2	297.9
7	0.79299	19.5637	1041.3	929.4
6	0.75638	16.0936	1013.4	447.1
5	0.71278	13.8441	1013.1	158.8
4	0.63261	6.6711	937.9	453.5
3	0.44731	0.3069	661.6	688.4
2	0.23256	-3.6233	495.8	674.8
1	0.00000	0.0000	.	495.8

Looking at the graphic of the dispersion of farmers in the three-dimensional space, it was clear that 5 groups represented better the natural dispersion (Figure 5.3) with high proportion of the original variance. Group 1 (diamonds) were farmers with a monopolisation of decisions without participation of any other decision-making units. This group was the biggest one in the population (38.5%). The second biggest cluster was the Group 4 (Flags) (17.6%) that was conformed by farmers with a balance of decisions made Alone and decisions made by the Family. Farmers belonging to Group 3 (Pyramids) (16.5%) have a decision-making approach in which, along with decisions made by the farmers, some decisions were made in a Shared way with other people. A combination of decisions taken Alone and decisions

Delegated are likely to be found in farmers belonging to Group 5 (clubs) (15.3). Finally, the smaller group (2, 12.1%) (balloons) were farmers who make decisions in conjunction with the family members. These results show that monopolisation in decision-making was the most frequent decision-making approach. However the role of the family and other people within the farms seems to be very important since around 60% of the farmers acknowledged the participation of them in the farming decisions. The role of the family in conjoint decisions is quite important in around a quarter of the population (Groups 2 and 4).

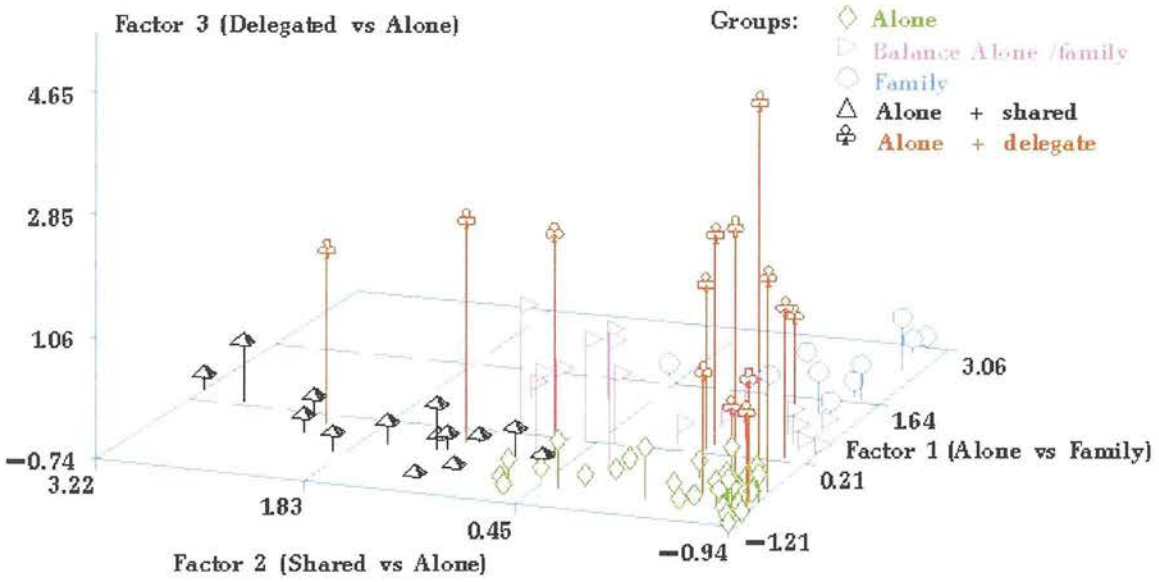

Figure 5.3. Dispersion of farmers in the three-dimensional space of decision-making approach and their respective cluster of membership

5.3.3 Relationships between decisions and the decision-making units

Table 5.6 shows the two-way table of frequencies between decisions and decision-making units (second database). Looking at the totals and percentages it can be seen that farmers made nearly half of the farming decisions showing the importance of the family members and people in the process. This result agrees with study reported by Ferreira (1997) in terms the level of importance of the family and other trusted people in the decision-making process and contrast with those studies showing monopolisation on behalf the farmers (Vail, 1982; Bokemeir and Garkovich, 1987).

However agrees with respect to the male preponderance since only 7 farmer (7.7%) were women in the present study.

Table 5.6. Two-way table of frequencies between decisions and decision-making units (second database)

Decision		Alone	Family	Shared	Delegated	Not apply
Replacement selection	n	44	22	20	4	1
	%	48.35	24.18	21.98	4.40	1.10
When to deworm	n	51	10	12	16	2
	%	56.04	10.99	13.19	17.58	2.20
Activities designation	n	55	15	9	8	4
	%	60.44	16.48	9.89	8.79	4.40
Herd grouping for feeding	n	42	9	20	8	12
	%	46.15	9.89	21.98	8.79	13.19
Amount of concentrate/cow	n	47	9	19	15	1
	%	51.65	9.89	20.88	16.48	1.10
When to inseminate a cow	n	40	6	13	19	13
	%	43.96	6.59	14.29	20.88	14.29
To use a credit	n	35	42	3	1	10
	%	38.46	46.15	3.30	1.10	10.99
Type of nitrogen fertiliser	n	38	9	24	11	9
	%	41.76	9.89	26.37	12.09	9.89
Change of land use	n	36	23	8	2	22
	%	39.56	25.27	8.79	2.20	24.18
To introduce a new pasture species	n	41	22	18	1	9
	%	45.05	24.18	19.78	1.10	9.89
When to mate a heifer for the first time	n	44	11	13	10	13
	%	48.35	12.09	14.29	10.99	14.29
Labour recruitment	n	58	17	7	6	3
	%	63.74	18.68	7.69	6.59	3.30
Which paddocks to graze and order	n	45	9	19	14	4
	%	49.45	9.89	20.88	15.38	4.40
When to run a California Mastitis Test	n	44	8	12	22	5
	%	48.35	8.79	13.19	24.18	5.49
Machinery purchase	n	45	31	5	3	7
	%	49.45	34.07	5.49	3.30	7.69
Amount of milk/calf	n	42	8	15	14	12
	%	46.15	8.79	16.48	15.38	13.19
How many replacement to raise	n	53	18	14	3	3
	%	58.24	19.78	15.38	3.30	3.30
Total	**n**	**785**	**271**	**241**	**166**	**175**
Percentage	**%**	**47.92**	**16.54**	**14.71**	**10.13**	**10.68**

This shows that although the farmer's authority was very important, monopolisation of decisions could not be assumed. 'Labour recruitment' was an example of decision almost monopolised by the farmer, while 'to use a credit' was an example of a decision frequently made by other decision-making units.

Family decisions were second in importance (16.5%) and decisions such as 'To use a credit' and 'Machinery Purchases' were more frequently made by this unit. Here the role of the family was more important than reported by Ferreira (1997). These results are similar to those reported by Berlan (1988) in terms of the high involvement of the family in decision related to investments and by Vail (1982) in terms of capital decisions. This also confront the point of view of the family as the real decision-making unit supported by Jones (1967), Dent (1995), and Errington and Gasson (1994).

Shared and Delegated decisions were still frequent in the decision-making process since around a quarter of the decisions are made under these categories. These results show that the influence of other actors is very important when making farming decisions.

Table 5.7. Rotated Factors of the relationship between the categories of decision-making approach (decisions level)

Decision-Making approaches	Factors		
	Fad1	Fad2	Fad3
Alone	0.07248	-0.06466	0.99349
Family	-0.80148	-0.51184	-0.21703
Share	0.18748	0.97129	-0.09926
Delegate	0.98490	0.07812	-0.00452
Eigenvalue	2.1548	1.1016	0.6560
Proportion	0.5387	0.2754	0.1640
Cumulative	0.5387	0.8141	0.9781

The second factor analysis (Table 5.7) demonstrated that the first 3 factors explained 97% of the original variance. Fad 1 was a dimension from family towards delegation. Therefore those decisions with low score in this factor were mostly made in family while those with high scores tended to be more delegated (this factor was labelled as "Family vs Delegated". Fad 2 represented a dimension towards shared decisions and against family, therefore the higher the score in this factor there more

frequent the decision was shared and the less in family ("Shared vs Family"). The decisions with high score in Fad 3 tended to be made more frequently by the farmer alone ("Alone").

The CLU analysis showed that decisions could be separated into 4 groups (Table 5.8) according to the decision-making unit involved. Figure 5.4 shows the dispersion of decisions in the three dimensional space formed by the Fads. Group1 (Italics bold) were decisions mostly delegated to other people different than the farmer and family. They seem to be operational management decisions that require some level of information that is normally known by the operators of the farms. They require the direct observation of the animals and the pasture in order to decide the best way to manage them. Group2 (Italics) were more technical decisions and the reason of sharing them is probably because the level of technical knowledge and experience required to make them. Group3 (normal) were decisions made by the farmer himself mostly related to labour decisions. Here the farmers as 'bosses' are represented. Finally Group 4 (normal bold) was a group of decisions made mostly by the family. They seem to be more strategic and high investment decisions.

Table 5.8. Clustering statistics for selection of the best number of clusters of decisions according to their decision-making approach

Number of Clusters	R-Squared	Cubic Clustering Criterion	Pseudo F	Pseudo t^2
10	0.963	.	20.4	4.9
9	0.943	.	16.6	.
8	0.916	.	13.9	4.4
7	0.888	.	13.2	7.5
6	0.860	.	13.5	1.4
5	0.822	.	13.9	7.6
4	0.751	.	13.1	7.0
3	0.521	-0.99	7.6	12.2
2	0.279	-1.12	5.8	6.8
1	0.000	0.00	.	5.8

These results indicate the patterns in which the decisions are likely to be made under general conditions. The extent in which they are actually made depends also on other variables including some farmers'/farms' characteristics and unique farm

conditions. This also demonstrates the necessity to focus the extension efforts towards different actors taking part of the decision-making process within the farm. So the farmers themselves should no longer be considered as the only target for technology transfer, training etc.

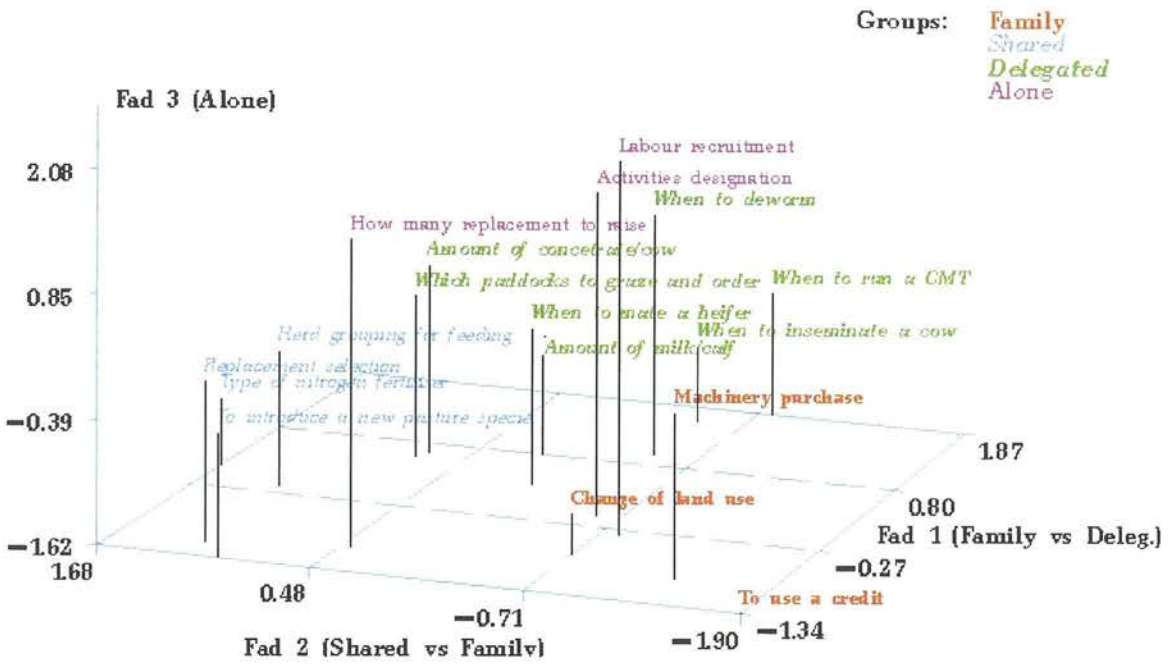

Figure 5.4. Dispersion of decisions according to the three-dimensional space of decision-making units involved and their cluster of membership

5.3.4 Relationship between the decisions' traits and the categories of decision-making approach

Table 5.9 shows the estimated parameters, the χ^2 and the odd ratios of the univariate models. The probabilities of decisions to be made within the Family seemed to be affected by all the decision traits. In this way Term increased the odds ratios at level 5 showing that very long-term decisions were more likely to be made in Family than the short or medium ones. The effect on milk yield seems to slightly increase the probabilities in favour of decisions made in family. Regarding to investments the probability of family making decision was very high at level 5.

Although the parameters in lower levels were not significant, there was a tendency to increase as the investment level increased. When decisions imply different levels of information the odds ratios showed that they increased as the information level increased up to level 4. When the level of information was very high, the probability of a familiar decision decreased significantly. This shows that there could be a threshold beyond which the role of the family becomes less important.

The probabilities of making decisions Alone were affected significantly only by the term of the decisions showing that the role of other decision-making units increased as the term increased. Although the rest of the traits had not a significant effect, there was a generalised negative tendency respect to the basal level 1 showing that all the traits could be affecting against of decisions taken alone.

Shared decisions seemed to be more likely in short to medium term decisions (less likely in long term), more likely only when the impact on milk production was very high (level 5), when low investments were involved in the decisions. The information requirement seemed not to clearly affect the probabilities towards shared decisions.

Finally the probabilities of delegation were very high in short to medium decision and very low in the long-term ones. The odds ratios were very high when the risk of impact on milk production was very low (level 2) and decreases when this risk was 3; at level 5 the parameter was not significant. A reduction in the probabilities is shown as the investment and information levels increase.

It should be said that the lack of a balanced design in the analysed matrix (different number of observations in each of the levels of the traits) could caused problems in terms of the level of significance within each one of the traits studied. Nevertheless, these results show some clear relationships between the intrinsic characteristics of the decisions and the level of involvement of the different decision-making. These traits seem to specially affect the role of the family in the decision-making process.

Table 5.9. **Logistic regression analyses of the relationship between decisions' intrinsical characteristics and the decision-making units involved**

CDMU	Family (dec1)				Alone (dec2)				Share (dec3)				Delegate (dec4)			
Variable	Param.	Stand. error	Pr > χ^2	Odd rate	Param.	Stand. error	Pr > χ^2	Odd rate	Param.	Stand. error	Pr > χ^2	Odd rate	Param.	Stand. error	Pr > χ^2	Odd rate
Intercept	-1.497	0.195	0.000	.	0.600	0.158	0.000	.	-2.296	0.262	0.000	.	-2.442	0.278	0.000	
Ter1	-0.680	0.266	0.011	0.506	-0.576	0.192	0.003	0.562	0.969	0.294	0.001	2.635	0.944	0.312	0.003	2.570
Ter2	-0.687	0.266	0.010	0.503	-0.457	0.192	0.017	0.633	0.849	0.296	0.004	2.338	0.875	0.313	0.005	2.399
Ter3	0.628	0.216	0.004	1.874	-0.516	0.178	0.004	0.597	0.494	0.288	0.087	1.639	-0.686	0.348	0.049	0.504
	r^2= 0.0845				r^2= 0.017				r^2= 0.011				r^2= 0.087			
Intercept	-1.235	0.088	0.000	.	0.193	0.074	0.009	.	-1.899	0.109	0.000	.	-2.239	0.124	0.000	
Efp1	-1.136	0.293	0.000	0.321	-0.145	0.172	0.403	0.865	0.183	0.243	0.452	1.201	1.140	0.219	0.000	3.120
Efp2	-0.123	0.278	0.660	0.885	0.222	0.230	0.335	1.248	0.234	0.311	0.453	1.263	-1.105	0.600	0.065	0.331
Efp3	-0.380	0.157	0.016	0.684	-0.147	0.121	0.229	0.864	0.658	0.159	0.000	1.931	0.020	0.204	0.921	1.020
	r^2= 0.024				r^2= 0.003				r^2= 0.020				r^2= 0.047			
Intercept	-1.816	0.104	0.000	.	0.191	0.072	0.008	.	-1.595	0.096	0.000	.	-1.784	0.103	0.000	
Inv1	-0.235	0.369	0.525	0.791	-0.065	0.236	0.785	0.937	0.514	0.276	0.063	1.671	-0.399	0.386	0.302	0.671
Inv2	0.342	0.227	0.133	1.408	-0.129	0.173	0.456	0.879	0.240	0.217	0.271	1.271	-0.491	0.290	0.090	0.612
Inv3	0.458	0.284	0.107	1.581	0.224	0.229	0.330	1.250	-0.070	0.307	0.821	0.933	-1.560	0.596	0.009	0.210
Inv4	1.081	0.158	0.000	2.948	-0.179	0.132	0.177	0.836	-0.516	0.203	0.011	0.597	-0.885	0.248	0.000	0.413
	r^2= 0.055				r^2= 0.003				r^2= 0.017				r^2= 0.032			
Intercept	-1.792	0.180	0.000	.	0.320	0.127	0.012	.	-1.928	0.189	0.000	.	-1.728	0.176	0.000	
Inf1	-0.320	0.279	0.240	0.726	-0.224	0.178	0.213	0.799	0.566	0.245	0.021	1.762	0.100	0.245	0.685	1.105
Inf2	0.362	0.219	0.100	1.436	-0.191	0.161	0.238	0.826	0.399	0.229	0.082	1.491	-0.508	0.245	0.037	0.602
Inf3	0.966	0.244	0.000	2.628	-0.274	0.198	0.167	0.760	0.143	0.287	0.619	1.154	-1.444	0.429	0.001	0.236
Inf4	0.541	0.226	0.015	1.718	-0.195	0.167	0.245	0.823	0.204	0.242	0.401	1.226	-0.526	0.256	0.040	0.591
	r^2= 0.035				r^2= 0.008				r^2= 0.004				r^2= 0.016			

5.3.5 Relationships between Shared and Delegated decisions and actors involved

The first SCA analysis produced the tables of frequencies of shared decisions and the categories of actors involved (Table 5.10). From this table it can be seem that technical advisors were involved in around 40% of the share decisions, while family members, acting as farm staff, participated in 36% of them. The external farm staff was only involved in 23.4% of these decisions.

Table 5.10. Two-way table of frequencies between shared decision and actors involved

Decisions		Agronomists	Vets	Animal Science	Farm staff	Family members	Total
Replacement selection	n	0	4	0	7	9	20
	%	0.00	20.0	0.0	35.0	45.0	
Herd grouping for feeding	n	2	2	5	7	4	20
	%	10.0	10.0	25.0	35.0	20.0	
Type of nitrogen fertiliser	n	7	1	5	2	8	23
	%	30.4	4.3	21.7	8.7	34.6	
To introduce a new pasture species	n	4	1	1	3	9	18
	%	22.2	5.5	5.5	16.6	49.9	
Total	**n**	**13**	**8**	**11**	**19**	**30**	**81**
	%	**16.0**	**9.8**	**13.5**	**23.4**	**36.9**	**100**

Figure 5.5 shows the bi-dimensional plot of the relationship between shared decisions and the actors involved. There was a clear relationship between very technical decisions and technical advisors. Herd grouping for feeding (HerdDiv); Type of Nitrogen Fertilizer (TypeNitr); and Replacement Selection (RepSel) were related to advisors in animal science, agronomy and veterinary respectively, while 'to introduce a new pasture species' was related to family members. Again family member was involved in long term high investment decisions. The farm staff was related to 'Replacement selection' probably because the level of knowledge of the heifers and cows.

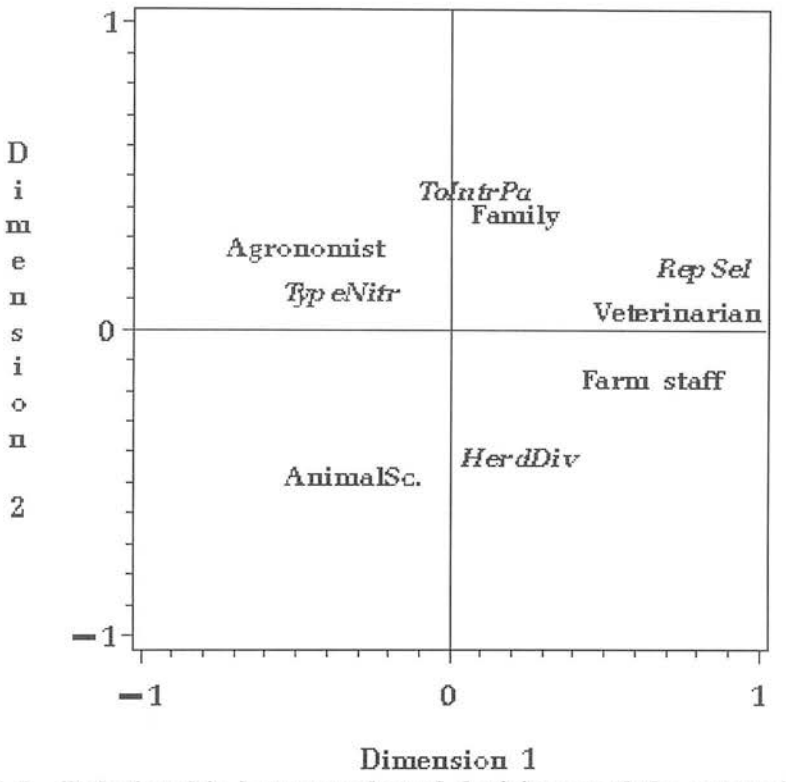

Figure 5.5. Relationship between shared decisions and the actors involved

According to the second SCA, delegated decisions were related to the external farm staff (45.4%) and family members (39.9%) and in low degree to technical advisors (14.5%), mostly veterinarians (Table 5.11).

Figure 5.6 shows that veterinarians were the only technical advisors delegated with some decisions. They were delegated with very technical ones such as 'When to mate a heifer for the fist time' (WhenMat) and 'When to deworm' (WheDew) probably as a result of the gynaecological exams and health programs manage by them respectively. The remaining decisions were mostly delegated to the farm staff and family members (also staff). These decisions include When to run a CMT (WhenCMT), the Amount of concentrates per cow (AmoCon), When to inseminate a cow (WhenIns), the Amount of milk per calf (AmoMilk) and Which paddocks to graze and order (WhichPa). Looking at the original traits, these decisions tend to have short-term effects and low investments (except AmoCon) and some of them require medium to high information levels mostly concerning to the animals. This result is in agreement with the study of Errington (1986) in terms of delegation of

operational decisions to the farm staff due to the informational advantage of them over the farmer.

Table 5.11. Two-way table of frequencies between delegated decisions and the actors involved

Decision		Agronomists	Vets	Farm staff	Family	Total
When to deworm	n	0	7	3	6	16
	%	0.0	43.7	18.7	37.4	
Amount of concentrate/cow	n	1	0	8	6	15
	%	6.6	0.0	53.3	40.0	
When to inseminate a cow	n	0	1	10	8	19
	%	0.0	5.2	52.6	42.0	
When to mate a heifer	n	0	4	3	3	10
	%	0.0	40.0	30.0	30.0	
Which paddocks to graze and order	n	0	0	7	7	14
	%	0.0	0.0	50.0	49.9	
When to run a CMT	n	1	0	13	8	22
	%	4.5	0.0	59.0	36.3	
Amount of milk/calf	n	1	1	6	6	14
	%	7.1	7.1	42.8	42.8	
Total	**n**	**3**	**13**	**50**	**44**	**110**
	%	**2.73**	**11.82**	**45.45**	**39.9**	**100.00**

This evidence demonstrates that the role of the family, acting as farm staff was quite important in both shared and delegated decisions. The external farm staff was more important in delegated decisions probably due to the level of information they have in terms of animals and pasture condition. However, since shared decisions are more technical, the role of the farm staff was relegated to the last place while the technical advisors became more important. With some the exceptions, the latter actors were not allowed to make any decisions by themselves.

The fact that non-trivial decisions concerning to nutritional and grazing management are frequently delegated to the farm staff has an important implication in term of resources management strategies. Technologies oriented to optimise the nutritional management strategies, such as simulation and multiple criteria optimisation models, will have a limited impact unless this delegation process is well

known and training is addressed to this other actors of the decision-making process. This also has implications in term of definition of target for technology transfer strategies.

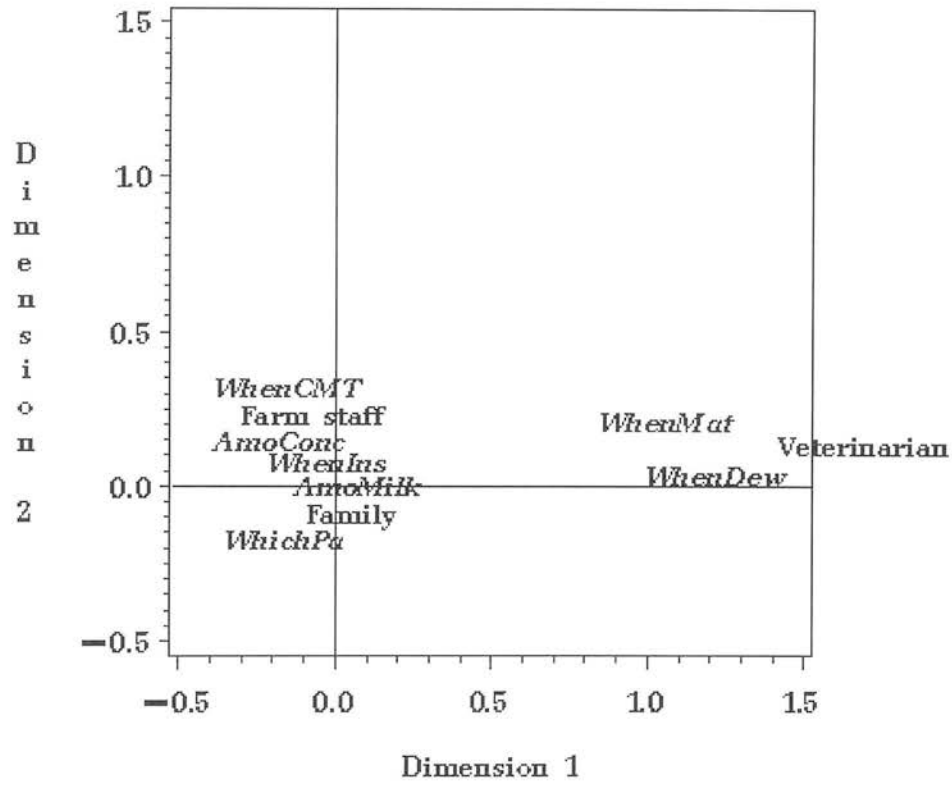

Figure 5.6. Relationship between delegated decisions and the actors involved

5.4 Concluding remarks

The level of dedication to farming, the educational level, and the dimension of the farms (area and herd size) are the farmers'/farms' characteristics with the biggest impact on shaping the farmers' decision-making approach. However the power of prediction from these variables is very low showing the necessity for looking for more variables that could explain more of the observed variance in the population.

From the point of view of the population, the monopolisation of decisions by the one decision-maker (mostly the male) is the most frequent decision-making approach. However other approaches including the participation of the family and other people in shared and delegated decision are still very frequent. From the point

of view of decisions per se, they are made by the farmer only in a half of the cases while the other half is made by other actors. These finding shows that neither the farmer nor the family could be assumed as the real decision-making units but a combination of actors from inside and outside the farm family.

The classification made in this paper shows that few groups of farmers are needed to classify the population of Costa Rican farmers into well defined categories of decision-making approaches.

Apart from the farmers/farms' characteristics, the extent to which different actors take part on the process also depends on the decisions' intrinsic characteristics.

Shared decisions are more related to technical advisors and family members, while delegated decisions are related to the farm labour and the family members acting as labour.

In general terms, it could be concluded that evidence presented demonstrates that technology transfer activities, including extension and training, have been targeted towards just one of the actors involved within the decision-making process. Therefore it is necessary to design 'tailor made' strategies that take into account all the actors involved in order to ensure the best rate of technology adoption and development.

Including other actors as targets has important implications in term of choosing for the best media, language, message to reach and have an impact on all the people interacting in the decision-making process and therefore in the adoption process within or outside the farm.

As in the case of objective profiles defined in the last chapter, the decision-making approach profiles provide another dimension of the farmer's personality and therefore, its impact on management and performance should be quantified. This will be done in chapter 7.

Chapter 6 The role of personal information sources in the decision-making process*

Abstract

The attitudes of farmers in relation to the importance of different people as information and opinion sources (InfS) for different phases of the decision-making process were studied in 91 Costa Rican dairy farmers. The InfS studied were: *Family members*, *Other farmers*, *Technical advisors*, *Farm staff* and *Commercial agents*, while the phases were: Problem detection, Seeking for problem solutions, Seeking for new practices and Seeking for opinion. A Multidimensional Preference Analysis (MDPREF) was used to obtain a two-dimensional maps of preference of the farmers. A Factor Analysis was used to define new variables representing the farmers' predilection towards the InfS. A Canonical Correlation Analysis was performed to find-out simple and canonical correlation between farmers'/farms' characteristics and the InfS preferences. Informational profiles in the population were defined through Cluster Analysis.

MDPRED demonstrated that *Family members* and *Technical advisors* were the most preferred InfS. However their relative importance changed throughout the phases. *Farm staff* was rated in third place and their role became more important in the 'Problem detection' phase. *Other farmers* and *Commercial agents* were, in general, the less preferred information sources. The former became slightly more important in the 'Seeking for new practices' phase. The Canonical Correlation Analysis found 3 low-medium correlations between the farmers'/farms' characteristics and the InfS factors. These correlations showed that the farmers' age, educational level and dedication and the farms' characteristics of area, herd size and distance to population centres had a significant influence on the preference of the farmers towards different information sources. The Cluster Analysis found nine groups of farmers according to their preferences.

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* based on Solano, C., Herrero, M., León, H. and Pérez, E. (2000) The role of personal information sources in the decision-making process by Costa Rican dairy farmers. Agricultural Systems. (submitted)

6.1 Introduction

From the literature review in chapter 2, it was concluded that farmers prefer personal sources of information. Family members and extensionists/advisors are the most used information sources and therefore they conform the basis of Trusted People group. It was also concluded that some question remained that need to be answered, these were: 1-What is the relative importance of different Trusted People in different phases of the decision-making process?; 2-Which are the farmers'/farms' factors affecting the preponderance of some personal information sources over the other?; 3-How farmers can be classified ?

Answering these questions means a better understanding of the informational flows and preference of the farmers that represent key information to identify the proper targets and media in technology transfer activities. This chapter is an attempt to provide empirical evidence and methodologies that could lead to answering these questions and, on the other hand, define another dimension of the farmer's personality and managerial capacity that could be subsequently related to management and performance of the farms.

6.2 Materials and Methods

6.2.1 Measuring attitudes towards the personal information sources

Attitude of farmers towards different categories of information sources (InfS) for different decision-making phases were measured using a Simple Rating Scale technique (Foddy, 1993). The InfS categories were: *Family members*, *Other farmers*, *Farm staff*, *Technical advisors* and *Commercial agents* while the decision-making phases were: Problem Detection, Seek for problem solutions, Seeking for new practices and Seeking for opinion. Five cards written with each InfS category were given to the farmers and they were asked to rate them in a rule scaled from 1 to 5 (1 meaning not important and 5 meaning very important). Explanations of the meaning of the card, the scale and the phases of decision-making were given before the exercise started. This exercise was repeated four times, one for each decision-making phase. The rates given to each InfS throughout the phases were simultaneously

entered into the Edical Program (chapter 3). Figure 6.1 shows the rating score exercise.

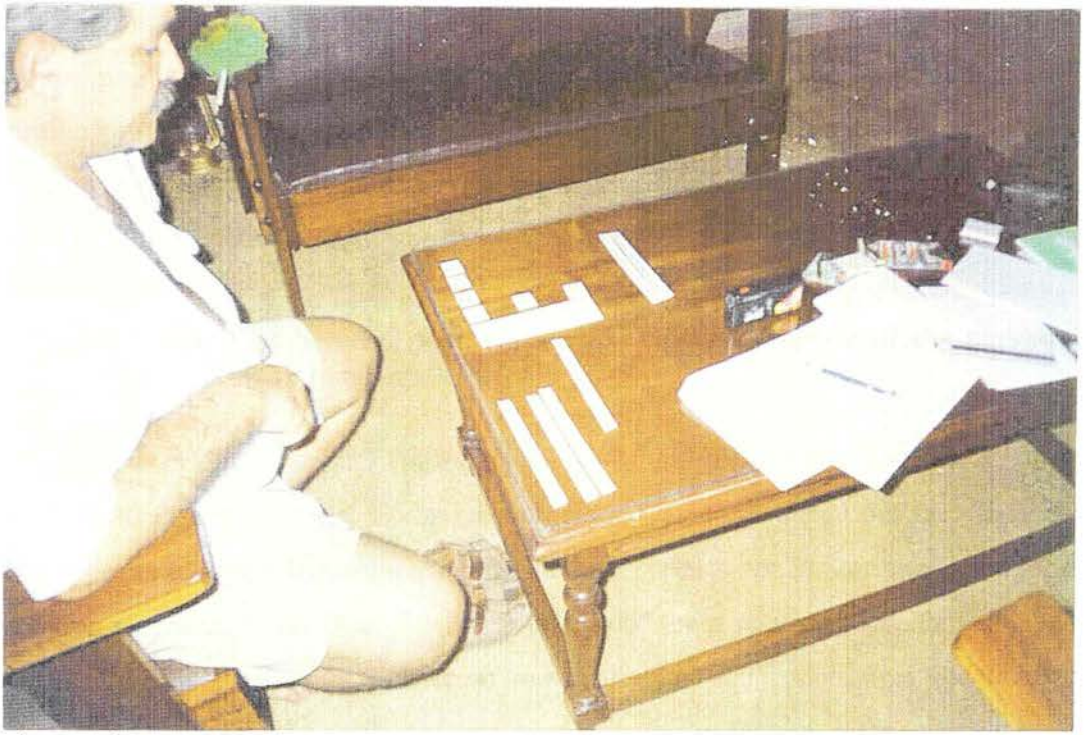

Figure 6.1. A farmer rating the importance of the personal information sources in each step of the decision-making process

6.2.2 Statistical analyses

6.2.3 Multidimensional Preference Analysis

This analysis was developed by Carroll, (1972) and is a Principal Components Analysis of a data matrix with columns that correspond to people and rows that correspond to objects. The data are ratings or rankings of each person's preference towards each object (SAS, 1994). In this case, people were the farmers and the objects were the InfS categories. In order to present the database adequately, the first step of the analysis was to transpose the data so that InfS became rows and farmers' became columns (the opposite of a traditional multivariate matrix). The second step was a Prinqual Analysis (Principal Components Analysis of qualitative data) (SAS, 1994) that attempted to optimise the data correlation matrix to the first two principal components using a monotonic optimal transformation. In other word, reducing the

dimensionality by maximising the variation can be explained by the factors. The analysis produced biplots (plots that show the relationships between the row and the columns of a data matrix) whose axes are defined by factors that represent the farmers' preference space. Using these plots, it was possible to identify clusters of farmer points near to InfS points, or clusters of InfS points, showing farmers with similar preference towards the same InfS categories or InfS with similar preference among the farmers. Four biplots, one for each phase of the decision-making step were produced.

6.2.4 Relationships between farmers'/farms' characteristics and the personal information sources used

Using the original database (farmers were rows and InfS were columns), a Factor analysis using the Principal Components method was used to find out factors (Fats) that represented the relationships among the InfS preferences. A Varimax orthogonal rotation was used to facilitate the interpretation of these relationships. This analysis produced factor scores by farmer as new variables that represented the farmer' preference towards the InfS categories. Once these factors were calculated, a Canonical Correlation Analysis (CCA) was performed to find out relationships between the farmers'/farms' characteristics i.e. age, level of dedication to farming, educational level, pasture area and the number of milking cows with the preference factors scores. This analysis produced both simple and canonical correlation matrixes.

6.2.5 Defining the farmers' Trusted People profiles in the population

Using the farmer's scores for each factor, a Cluster Analysis (CLU) was used to define groups of farmers with similar InfS preferences and for defining the population profiles (Informational Profiles). The Ward clustering method was used to calculate the Euclidean distances among the groups. The final number of groups was defined by looking for a consensus of four statistics: high Determination coefficient (r^2), a peak in the Cubic Clustering Criterion (CCC) and Pseudo F statistic (PsF) and a small value of Pseudo T statistic (PsT) (SAS, 1994). In order to interpret the profiles of farmers within each group, the means and confidence intervals (90%) of

the original rates for each InfS categories within each group were calculated. A series of labels were assigned according to the groups' traits in order describe the Trusted People Profiles of each group.

Figure 6.2 summarises the methodology used to analyse the information.

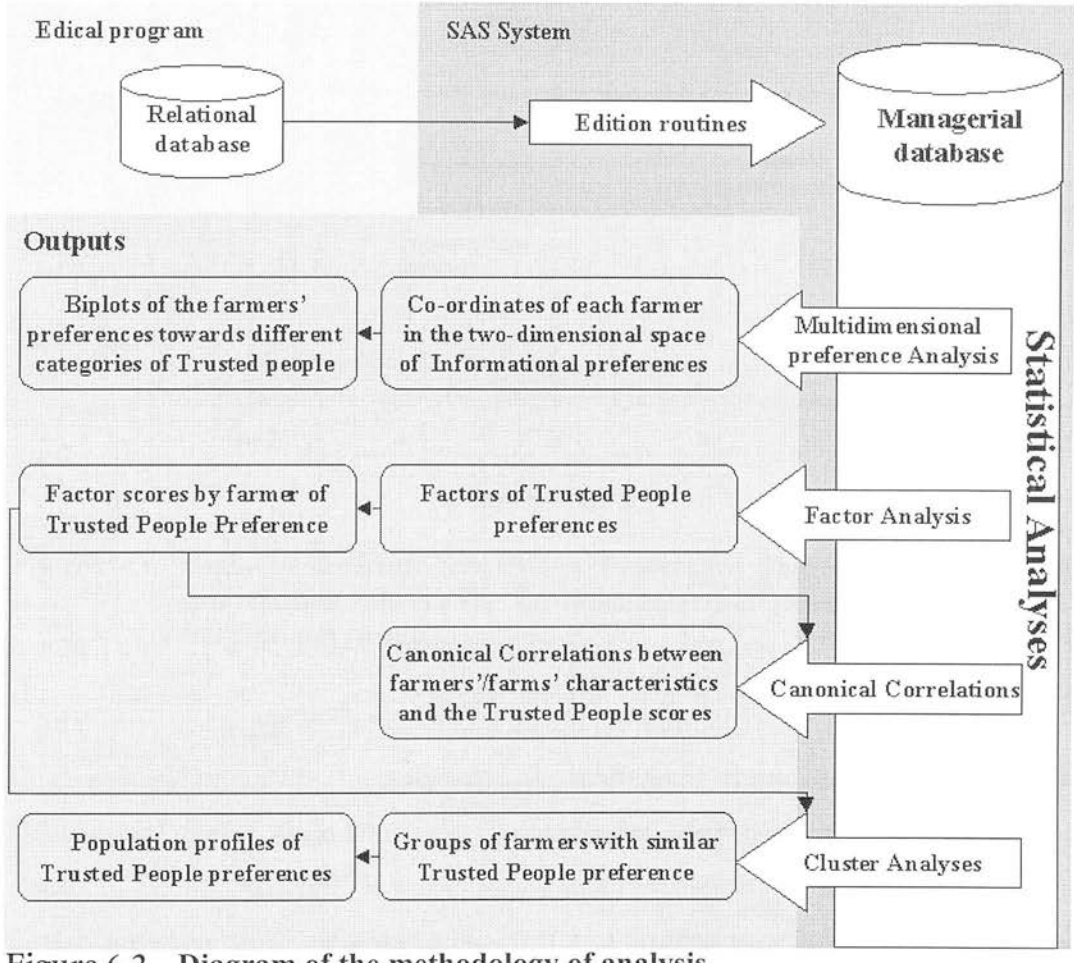

Figure 6.2. Diagram of the methodology of analysis

6.3 Results and discussion

6.3.1 Multidimensional Preference Analyses

In general terms it was found that most of the farmers preferred both the *Technical advisors* and *Family members* as information sources regardless of the step of the decision-making process analysed. The importance of the other InfS categories slightly changed throughout the steps.

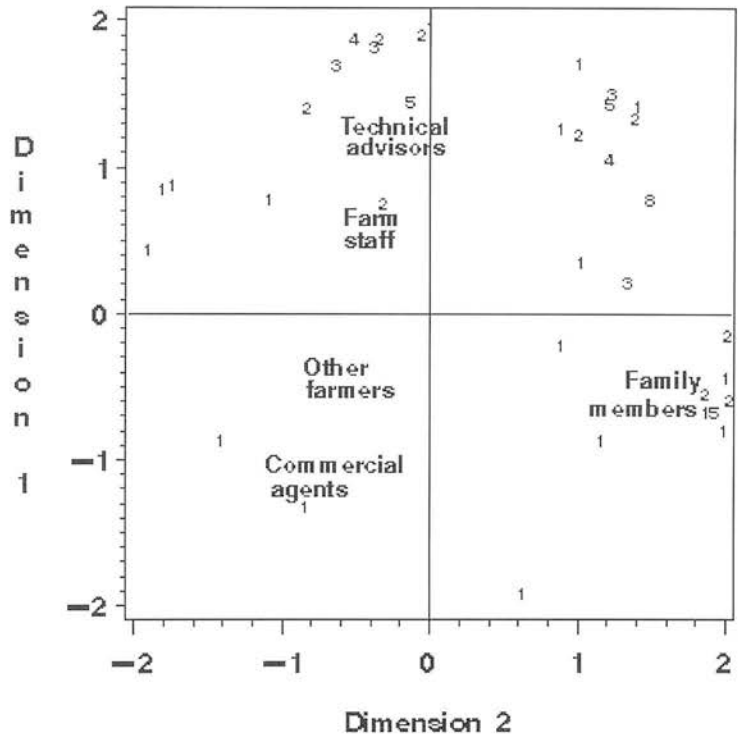

Figure 6.3. Biplot of the Multidimensional Preference Analysis of the personal information sources for 'Problem detection' (numbers inside represent frequencies of farmers).

Analysing each phase separately, it could be seen that for 'Problem Detection' (Figure 6.3) Dimension 1 represented the preference from *Technical advisors* to *Commercial agents* while Dimension 2 represented the preference from *Commercial agents* to *Family members*. It was apparent that the majority of farmers preferred the *Family members* since there was a big cluster of farmers very near to this category in the right-lower quarter. In the top-left quarter there is a group of farmers who preferred the *Technical advisors* and they were slightly in favour of the *Farm staff*. The *Farm staff* obtained its higher level importance in this step of the decision-making process. A big proportion of farmers preferred both *Family members*, *Technical advisors* and *Farm staff* (Top-right quarter) and just two farmers preferred *Other farmers* or *Commercial agents* for 'Problem Detection'.

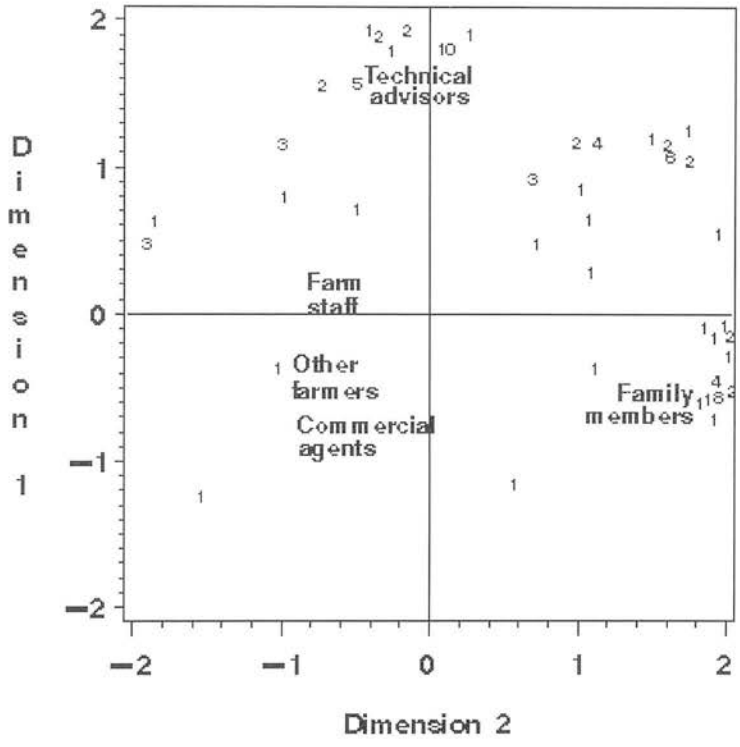

Figure 6.4. Biplot of the Multidimensional Preference Analysis of the personal information sources for 'Seeking for problem solutions' (numbers inside represent frequencies of farmers).

A very similar pattern was seen for 'Seeking for problem solutions' (Figure 6.4). However, it was evident that the preference towards the *Technical advisors* increased because of the high frequency of farmers around this category and the reduction in the frequencies around the *Family members*. In this step the role of the *Farm staff* category seems to be reduced. No significant changes in preference were observed towards *Other farmers* and *Commercial agents*.

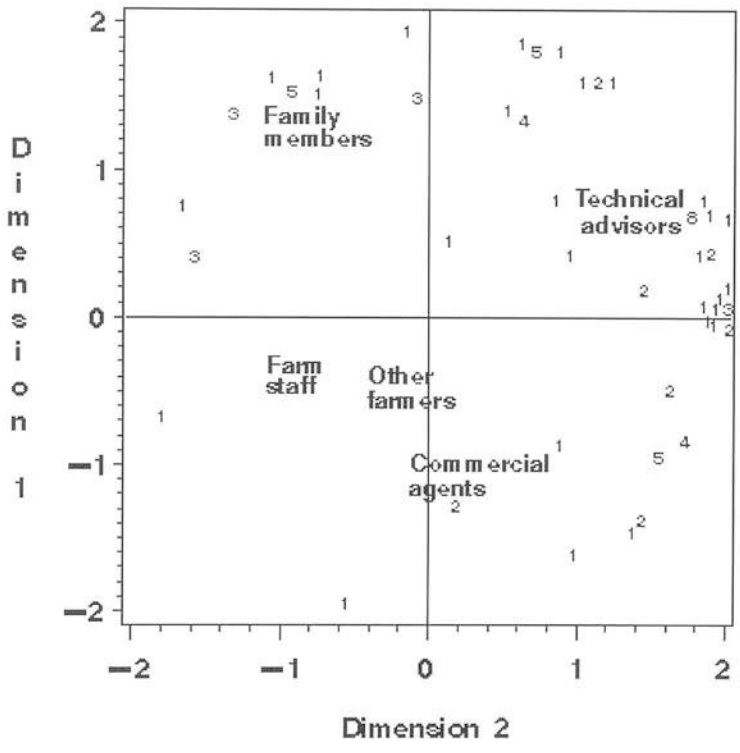

Figure 6.5. Biplot of the Multidimensional Preference Analysis of the personal information sources for 'Seeking of new practices' (numbers inside represent frequencies of farmers).

Figure 6.5 shows that for 'Seeking for New Practices', Dimension 1 represented the preference from *Commercial agents* to *Family members* while Dimension 2 represented the preference from *Farm staff* to *Technical advisors*. It can be seens that the preference of the farmers in this phase changed significantly in favour of the *Technical advisors* and that the importance of the *Family members* was evidently reduced. The preference towards the *Commercial agents* became more important as judged by the farmer frequency near to this category. It was in this phase where this InfS category obtained its biggest preference among the farmers. A low preference was observed for the *Other farmers* and *Farm staff*.

Finally Figure 6.6 demonstrates that for 'Seeking for Opinion', no farmer seemed to prefer other InfS than *Technical advisors* and *Family members*. The frequency of farmers around the *Family members* point indicated the high level of importance of the *Family members* as opinion source. A small proportion of farmers laid near to the *Technical advisors* category showing their limited rate as primary opinion source.

The frequencies of farmers in the top-right quarter indicated that a significant proportion of the farmers also preferred a combination of *Family members* and *Technical advisors* as personal information sources.

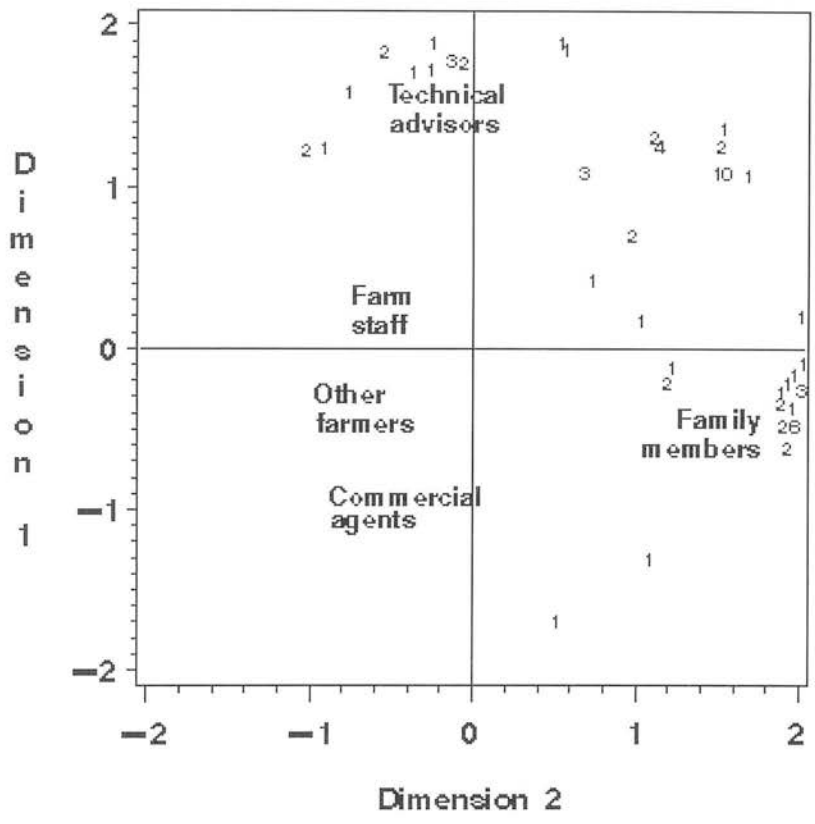

Figure 6.6. Biplot of the Multidimensional Preference Analysis of the personal information sources for 'Seeking for opinion' (numbers inside represent frequencies of farmers).

These results show that personal information sources for Costa Rican dairy farmers are a combination of *Technical advisors* and *Family members* and that their relative importance changes throughout the phases of the decision-making process. This is in agreement with the study reported by Sutherland at al (1996) and Blum (1989) with respect to the importance of these two categories of personal information sources in several activities of the decision-making process. On the other hand, this is in agreement with the findings of Ford and Babb (1986) regarding to the importance of the *Family members* but disagree with respect to the limited importance of the *Technical advisors* reported by them.

The privileged position of *Technical advisors* and *Family members* demonstrated their strategic role in technology transfer, extension and training activities. It also demonstrated the necessity of redefinition of the extension strategies in such a way that the most preferred categories of information sources become other targets and not only the farmers. This also applies to the *Farm staff* since their role is quite important during the 'Problem detection' phase. Well trained *Farm staff* in 'Problem detection' could have a big impact on the whole process and therefore on the development of the farms.

6.3.2 Relationships between farmers'/farms' characteristics and the personal information sources used

The Factor Analysis found that 5 factors explained around 70% of the original variance and that each factor represented the preference towards each InfS category in all the steps studied. Fat1, Fat2, Fat3, Fat4 and Fat5 represented the preference towards *Family members*, *Other farmers*, *Farm staff*, *Technical advisors* and *Commercial agents,* respectively (Table 6.1).

The CCA found three medium significant canonical correlations. The interpretation was made looking at the correlations between the original variables and their respective new canonical variables (CCVs and FCVs) and then the relation between them (Table 6.2).

Table 6.1. **Rotated factor patterns for the personal information sources**

Activity	Informational sources	Fat1	Fat2	Fat3	Fat4	Fat5
Problem detection	*Family members*	0.866	0.064	0.005	-0.191	-0.055
	Other farmers	0.101	0.851	0.121	0.080	0.033
	Farm staff	-0.089	0.074	0.778	-0.051	0.183
	Technical advisors	0.069	0.112	-0.033	0.734	0.025
	Commercial Agents	0.061	0.155	-0.011	0.176	0.522
Seeking for Problem solution	*Family members*	0.886	0.003	-0.056	-0.121	0.092
	Other farmers	-0.031	0.848	0.058	0.156	0.188
	Farm staff	-0.120	0.160	0.850	0.002	0.154
	Technical advisors	-0.322	0.171	0.110	0.756	0.093
	Commercial Agents	0.085	-0.029	0.269	0.123	0.754
Seeking for New practices	*Family members*	0.873	-0.065	0.124	0.017	-0.133
	Other farmers	0.017	0.837	0.115	0.068	0.064
	Farm staff	0.260	0.027	0.814	0.019	-0.052
	Technical advisors	-0.219	0.104	-0.028	0.797	0.066
	Commercial Agents	-0.126	0.104	0.058	-0.061	0.854
Seeking for Opinion	*Family members*	0.793	0.052	0.031	-0.147	0.232
	Other farmers	-0.042	0.788	0.090	0.165	0.078
	Farm staff	0.066	0.141	0.819	0.139	0.086
	Technical advisors	-0.129	0.082	0.067	0.834	0.175
	Commercial Agents	0.236	0.204	0.222	0.387	0.475
Statistics	Eigenvalue	4.682	3.662	2.263	1.865	1.480
	Difference	1.020	1.399	0.398	0.385	0.585
	Proportion	0.234	0.183	0.113	0.093	0.074
	Cumulative	0.234	0.417	0.530	0.624	0.698

The first canonical correlation showed that as the age and the level of dedication to farming decreased and as the dimension of the farm and the educational level of the farmer increased, the role of the family was less important, while the role of the *Farm staff* and *Technical advisors* became more relevant. This could be explained by the fact that young farmers tend to have a higher educational level and are likely to be professionals. Therefore their dedication to farming is lower because they are involved in other economic and social activities. These factors can produce two effects: 1-The Family does not live at the farm as a consequence of the other economic activities, they live probably in cities, 2-The farmers disassociate the family with the farm due to the educational level. The size of the farm in terms of area and herd size increases the necessity of people with managerial skills; increases

the amount of information required to make decisions and increases the technical requirement of the farm. All these factors together increase the role of the *Farm staff* and the *Technical advisors* in the decision-making process. Another explanation of this relationship is that larger farms are more able to pay *Technical advisors* and that well-educated people tend to trust in other well-educated people such as the *Technical advisors*. Finally, taking into account the size of the farm and the level of dedication of the farmer, the increment in the importance of the *Farm staff* and *Technical advisors* is an effect of the farmers' absence.

Table 6.2. Correlation matrixes of farmers'/farms' characteristics and Fats with their respective canonical variables

Canonical variables of Farmers'/farms' characteristics			
	CCV1	CCV2	CCV3
Distance	-0.0212	0.6837	0.1319
Age	-0.3104	0.2424	-0.1997
Dedication	-0.4066	0.6104	-0.2501
# Cows	0.5237	0.3344	0.2715
Pasture area	0.3513	0.4661	0.6488
Education	0.9112	-0.0422	-0.3489
Canonical variables of Fats			
	FCV1	FCV2	FCV3
Fat1	-0.7230	0.6597	-0.1631
Fat2	0.2650	0.3984	-0.1734
Fat3	0.4125	0.5658	0.5577
Fat4	0.4828	0.2907	-0.5516
Fat5	-0.0622	0.0375	0.5728
Correlation	0.5621	0.5303	0.3596
Pr>F	0.0001	0.0011	0.1137
PredP	0.0632	0.1194	0.1453

PredP is the variance of FCVs explained by CCVs (prediction power)

The second canonical correlation showed that as the distance of the farm to population centres, the level of dedication to farming and the size of the farm increased, the role of the *Family members*, *Other farmers* and the *Farm staff* increased. In other words, Dedicated farmers in distant and large farms tend to have a Trusted People group composed by *Family members*, *Other farmers* and *Farm staff*. This result shows how the distance from population centres makes farmers to be more dedicated to farming regardless of the educational level. These two factors can

produce either a reduction in the necessity of *Technical advisors* due to the presence of the farmers in the farm, or make the technical services less available and more expensive due to the distance. This can produce an effect on *Other farmers* as a consequence of the dedication, since visits between farmers could be more frequent due to the presence of the farmer in the farm and the social closeness among them. This, besides the absence of other technical information sources, makes the role of *Other farmers* in the decision-making process become more important. The role of the *Family members* increases in these conditions probably due to a higher dedication level of the *Family members* to farming activities as a consequence of social values and of the low availability and facilities for off-farm, non-agricultural economic activities. The importance of the *Farm staff* could be explained in the same way as the previous correlation, that was a consequence of the increased information requirement in bigger farms.

The third canonical variable showed that the bigger the farm and the less educated the farmer, the more important the *Farm staff* and *Commercial agents* were. Simultaneously the role of the *Technical Advisors* became less important. This provides evidence of the close relationship between the farmers' educational level and the role of *Technical advisors* regardless of the size of the farm and the financial constraints of paying a professional (larger farms can afford this service in comparison to the small ones). It also proves that *Commercial agents* become more important when they are the only technical information source. Another explanation could lay on the marketing strategies, where exchange of technical knowledge in return for product purchasing is a common practice that improves the perception of the farmers in favour of these 'free' information sources.

Finally, the total variance explained by the three canonical variables only accounts for 14% demonstrating the low power of prediction of the information sources from studied farmers'/farms' characteristics and provides information of the necessity of identifying other key variables in order to increase this prediction power.

6.3.3 Defining the farmers' Trusted People profiles in the population

Table 6.3 shows the statistics used to decide the best number of clusters (groups). From the point of view of the t^2, there were good points at 3, 5, 7 and 9 groups since

this statistic decreased in these points. Pseudo F increased linearly as the number of groups increased, however at point 10 it decreased. The CCC statistic showed a peak at point 9. The R^2 explained more than 60% from point 9 upwards. Looking for consensus, it was decided that nine was the best number of clusters to divide to farmers' population according to their information sources preferences.

Table 6.3. Clustering statistics for selection of the best number of clusters

Number of Clusters	R-Squared	Cubic Clustering Criterion	Pseudo F	Pseudo t^2
10	0.66241	-1.1201	17.2	9.6
9	0.63486	-1.4330	17.4	5.0
8	0.59936	-2.0332	17.3	9.4
7	0.55815	-2.6933	17.3	9.9
6	0.50253	-3.8555	16.8	16.3
5	0.43588	-3.1268	16.2	11.8
4	0.35350	-2.7039	15.5	14.0
3	0.25821	-2.2221	15.0	11.6
2	0.13470	-2.3089	13.5	12.7
1	0.00000	0.0000	.	13.5

Figure 6.7 shows the arithmetic means of the rates of each of InfS category by cluster. Looking at the number of farmers within each cluster it seems that the analysis produced groups with similar size except groups 7 and 9 which are smaller and therefore they represent farmers with some unique preference arrangements.

Group 1 (tp1) was a group of farmers who do not have any special preference towards any of the information source categories, except a small tendency in favour of the *Technical advisors*. From this point of view they represent the most individualistic farmers who make all the phases in the decision-making process by themselves. This profile could be labelled as 'Technical advisors Trusters'.

Group 2 (tp2) was a group of farmers who have an strong predilection for the *Family members* as information sources while they do not trust any other InfS category. This profile could be labelled as 'Family trusters'.

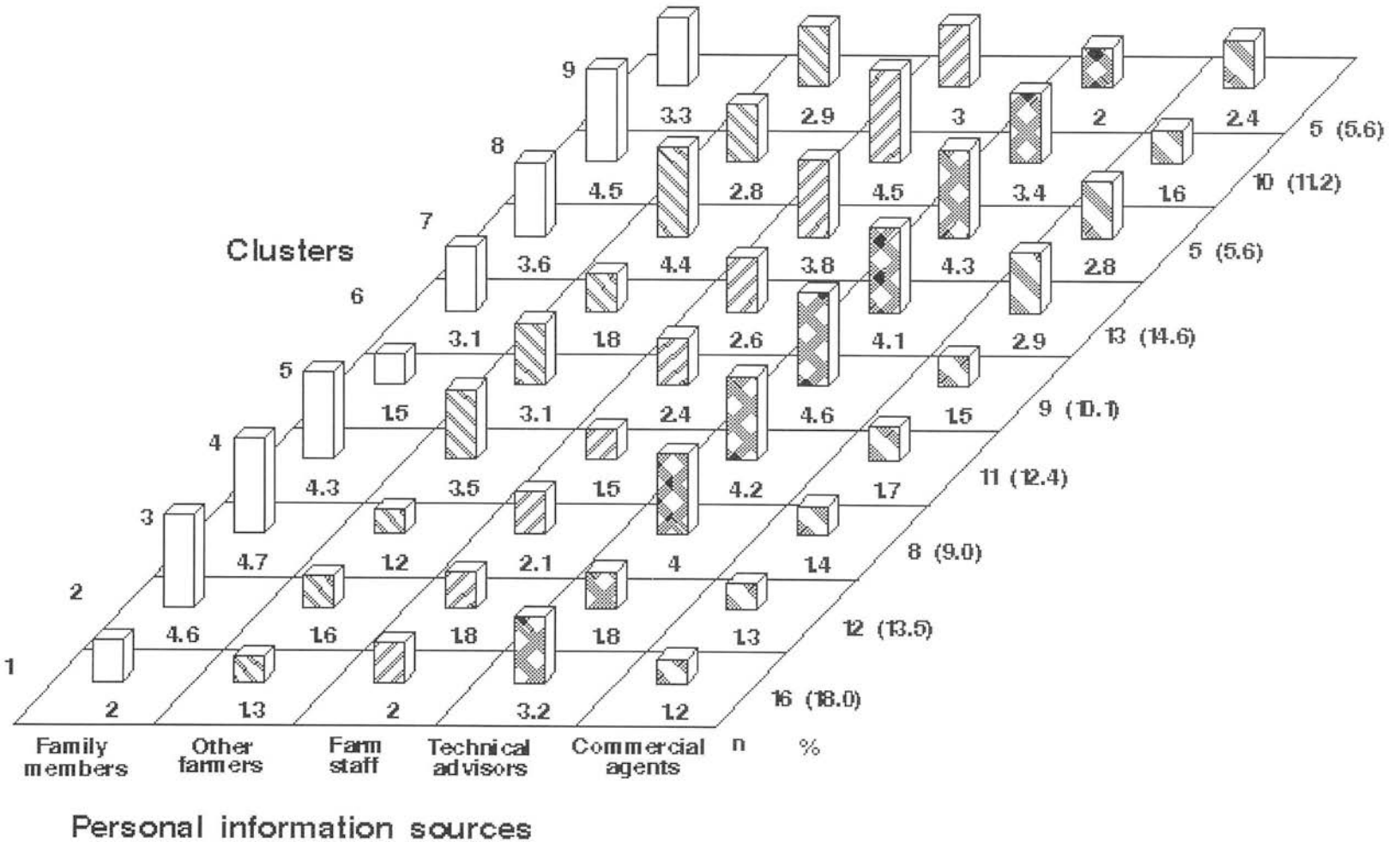

Figure 6.7. **Importance of informational sources for each cluster (Arithmetic means of rates)**

Both the *Family members* and the *Technical advisors* are incorporated together within the Trusted People group of the farmers belonging to the Group 3 (tp3) and this profile could be labelled as 'Family and Technical advisors trusters'.

Farmers in Group 4 (tp4), along with the *Family members* and *Technical advisors*, they trust in *Other farmers* as well. Their label could be 'Family, Technical advisors and Other farmers trusters'

Group 5 (tp5) were farmers who are strongly against the role of *Family members* in the process and they were attached to *Other farmers* and more strongly towards the *Technical advisors*. A label as 'Non Family pro Other farmer and Technical advisors trusters' can be assigned to them.

Farmers belonging to Group 6 (tp6) had a very similar profile to Group 3 in the sense they trust in *Family members* and *Technical advisors*, however they are the farmers who ranked the *Commercial agents* higher. They could be labelled as 'Family, Technical advisors and Commercial agents trusters'.

Farmers who trust in almost every information source categories, particularly *Other farmers* and *Technical advisors* composed Group 7 (tp7). Notice that this group is one of the smallest ones in the population. 'Multiple information sources trusters' could be a suitable label for these farmers.

Group 8 (tp8) was related to both *Family members* and *Farm staff*, being the latter the most preferred category. They are slightly in favour of *Technical advisors*. The label 'Family, Farm staff and Technical advisors trusters' was assigned to them.

Finally Group 9 (tp9) was the cluster in which the role of *Technical advisors* was ranked lower and general they were not attached to any InfS category. They were labelled and 'Non-Personal information sources trusters'.

Table 6.4 summarises the Trusted People Profiles in which the population of Costa Rican dairy farmers can be classified.

These results demonstrated the high variability of personal information preferences throughout the Costa Rican dairy farmers population. This agrees with the finding of Ferreira (1997) in terms of the relative importance of different members of the trusted people group throughout the decision-making units categories.

It was also demonstrated that farmers can be satisfactorily separated out into well defined groups representing different combinations of InfS. These Trusted People Profiles can be used as a classification when technology transfer and training activities are being designed in order to take into account all the different personal information sources used by each category. In this way the adoption and use of new improved technologies would be more likely and the impact of development would be more significant.

Table 6.4. Summary of the Trusted People profiles in the population

Cluster	n	%	Profiles
1	16	18.0	'Technical advisors Trusters'
2	12	13.5	'Family trusters'
3	8	9.0	'Family and Technical advisors trusters'
4	11	12.4	'Family, Technical advisors and Other farmers trusters'
5	9	10.1	'Other farmer and Technical Advisors trusters'
6	13	14.6	'Family, Technical advisors and Commercial Agents trusters
7	5	5.6	'Multiple information sources trusters'
8	10	11.2	'Family, Farm staff and Technical advisors trusters'
9	5	5.6	'Non-Personal information trusters

6.4 Concluding remarks

Family members and *Technical advisors* are the most common personal information sources for the majority of Costa Rican dairy farmers regardless of the decision-making steps involved. However, their relative importance changes significantly throughout the phases of the decision-making process.

The role of *Family members* is more important in 'Problem Detection' and in 'Seeking for Opinion' while the role of *Technical advisors* is evidently more important in 'Problem Solution' and 'Seeking for new practices'.

The role of other personal information source categories slightly changes throughout the decision-making phases where the role of *Farm staff* and *Commercial agents* becomes more important in 'Problem detection' and 'Seeking for new practices' respectively.

The relative importance of the personal information source categories is significantly affected by the farmers' characteristics of age, level of dedication to farming and educational level and for the farms' characteristics of distance from

population centres, numbers of cows and the area of the farmer. Nevertheless, the predictive power of these characteristics is low.

Well defined groups of farmers (Trusted People Profiles) exist in the population according to their preference towards different personal information sources. The fact that nine profiles are needed to classify the population is evidence of the high variability in the preferences towards these information sources.

The profiles defined provide another dimension of the farmer's personality and managerial capacity that could be related with the management and performance of the farm, as will be seen in chapter 7.

Chapter 7 Decision-making profiles, managerial capacity, management and performance*

Abstract

The aim of this chapter was to study the impact of a series of biographical variables and decision-making profiles, as representative of the managerial capacity of the farmer, on the management and performance of farms. This chapter integrates all the profiles developed in chapters 4, 5 and 6 that represent farmer's objectives, decision-making approaches and informational preferences. These profiles, along with some biographical variables and farms' characteristics were used as explanatory variables in a series of analyses of variance to evaluate the impact of these variables on the management and performance of the farm. Management was characterised in a factor analysis that included variables related to pasture management, nutritional and reproductive strategies, and some aspects of animal health. The performance indictors included milk yield per cow per day, milk yield per hectare per year, margin per cow per day, margin per ha per year, rate of return on working capital, and efficiency derived from a Stochastic Frontier Analysis.

Results demonstrated relationships between managerial capacity variables and management factors, and significant relationships between management factors and the performance of the farm. Limited effects of managerial variables on performance and efficiency were found. Results are discussed in terms of their implications for future development of decision-support systems and in terms of technology transfer activities.

* based on Solano, C., Herrero, M.; León, H., Pérez, E., Tole, L. and Fawcett, R.H. (2000) Decision-making profiles, managerial capacity, management and performance: A study of Costa Rican dairy farmers. Agricultural Systems, (submitted).

7.1 Introduction

In chapters 4, 5, and 6 Costa Rican dairy farmers were characterised by five profiles representing three dimensions of the farmer i.e. his/her objective orientations (economic, personal, familiar), decision-making approaches and preference towards different personal information sources. These 5 profiles, along with some biographical variables, constitute a more comprehensive proxy of the human component of the system, and therefore, a better representation of managerial capacity and objective orientation of farmer. However, this information is only valuable if some empirical evidence demonstrates relationships between managerial capacity and objective orientation with the way farmers manage their resources in order to obtain the desired performance of the farm. If it is the case, this characterisation would be a key element for research and extension activities. For the former, the objective orientation of the farmer can be used to improve or evaluate the level of success of the firm, define objective functions in decision-support systems and characterise the human component of the farm to be included within econometric models. For the latter, this information can be used to define targets, media and transfer strategies to ensure a higher level of adoption of technologies.

If no relationships are found, then it would be clear that other factors, e.g. resources and environment, are the ones which actually affect and constrain the adoption of technologies.

The literature review in chapter 3 showed that economists have made good progress in the development of algorithms to measure efficiency. However, the representation of the human component within the model has been very limited and narrow.

The aim of this chapter is to present some empirical evidence for the impact of an extended representation of the managerial capacity and objective orientation of the farm's decision-making unit on the management and performance of dairy farms in Costa Rica.

7.2 Materials and Methods

7.2.1 Characterisation of the farms' management practices and performance indicators

As explained in chapter 2, the questionnaire in the Edical software includes information on resources, labour characteristics, aspects of the farmer decision-making and management. The latter section includes information on herd grouping for feeding; grazing areas; nutritional management of each feeding group; pasture management of each grazing area; pre-weaning practices, reproductive practices, health practices and genetics aspects.

In the first step of the interview, farmers defined feeding groups in terms of the criteria for grouping, limits, and number of animals in each group. The second step defined the grazing areas including their size, type of use (grazing or cutting), pasture species and the groups of animal grazing each area. Once these two components were defined, the nutritional management of each feeding group was defined in term of feeds used, and amount of feeds offered (expressed as kg per group or animal or in terms of the milk/concentrate ratio). Gross purchases of feeds were also recorded. The grazing management of each area was defined in terms of the number paddocks, rotation length and the amount and frequency of organic and inorganic fertilisation applications.

For pre-weaning practices, information related to the period of milk consumption and daily milk intake were collected. Reproductive practices included: the frequency of reproductive examinations, post-calving treatments, heat detection practices, and heifers first service strategies. The health section included information about prevention and diagnosis practices for mastitis and lameness problems, as these represent two of the most costly diseases in terms of reduction of production (Pérez, personal communication) as in terms of cow culling (Beaudeau *et al*, 1993). Finally, the genetics section stored information on breeds and their proportions within the herd, replacement and culling rates, and artificial insemination percentages out of the total matings.

A relational database was designed for Edical for enabling links between the feeding groups and grazing areas with nutritional and grazing management practices. Several data interchange routines were included throughout different sections of the questionnaire in order to increase the quality of data and reduce the amount of time involved.

Management scores

A series of scores were constructed to represent several management practices of the farms. These practices were mostly characterised by qualitative variables including binomial (yes/no) and other categorical variables. The scores were calculated by assigning different weights according to values or categories that each management variable took. Some scores were derived by adding different sub-scores for different aspects of the same management practice. In some cases, factor analyses were used to summarise several variables into a few factors and to transform the qualitative variables into aggregated quantitative, normally distributed and independent variables.

The quantitative variables were not transformed and were introduced directly into the analysis.

Managerial supports scores and factors

1. **Score of technical advising (ScTeAd)**: This was calculated by assigning values according to the frequency of visits of technical advisors: 0 for never at all, 1 for 11 or less and 2 for more than 11 visits per year. This was done for veterinarians, agronomist and animal science advisors separately and finally added to calculate the overall technical advising score. The minimum possible score was 0 for farmers without technical advising, and the maximum possible score was 6 for farmer with the three types of technical advisors with 12 or more visits per year each.
2. **Score of record comprehensiveness (ScReKe)**: This score was calculated by adding a value of 1 if the following aspects in the record keeping system were available: individual milk yield; individual reproductive events; replacement

growth; disease incidence; pasture management and production; California Mastitis Test; individual reproductive examinations and lameness problems incidence. The minimum possible score were 0 for farmers without record keeping and the maximum possible value was 8 for farmers using all the items.

3. **Score of record type (ScReTy)**: This score was derived by assigning values according to the record keeping type: 0 for none, 1 for daily book, 2 for general book, 3 for individual files, 4 for computer without specialised software and 5 for computer with specialised software (management information e.g. VAMPP), respectively. The maximum value was 5.

These scores were introduced in a Factor analysis (SAS, 1994) using a Principal Components method to produce two new variables representing the managerial supports used by the farmers. The factors were then rotated using a Varimax orthogonal rotation in order to facilitate their interpretation. Factor patterns are shown in Table 7.1. The first factor (FaRec) is positively related to the type and comprehensiveness of the record system, while factor 2 (FaTech) represents the technical advice level of the farms.

Reproductive and health scores and factors

1. **Score of gynaecological examinations (ScGeEx)**: This score measures the intervals between reproductive examinations, assigning the following values: 0 for never at all, 1 for more than 90 days, 2 for between 60-90, 3 for between 30-60 and 4 for less than 30 days interval. The maximum possible value was 4.
2. **Score of post-calving treatments (ScPcTr)**: This score was calculated by adding a value of 1 if the following reproductive practices were used: intra-uterus antibiotics treatments; hormones for heat induction; heat synchronisation in heifers; heat synchronisation in cows; embryo transfer and heat detection devices. The minimum possible score was 0 for farmers without any of these practices and the maximum possible score was 6 for farmers using all of them.
3. **Score of artificial insemination (ScAi)**: This score was calculated by assigning the following values: 0 for natural matings, 1 for less than 75% and 2 for more

than 75% of matings made by artificial insemination. These thresholds were defined according to the distribution of the variables in the database. Separated values were assigned to heifers and cows and then added to obtain the final score. The minimum possible score was 0 for farms with only natural matings in heifers and cows and the maximum possible score was 4 for farmers 100% artificial insemination in both cows and heifers.

4. **Score of lameness problems prevention and diagnosis (ScPdLa)**: This score was calculated by adding three sub-scores. The first assigned a value of 1 for the use of foot-baths to prevent lameness diseases. The second assigned values according to the strategy of hoof trimming: 0 for never at all, 1 for only when lameness problems arise, 2 for once a year when drying out the cow, and 3 for frequently during the year. The third accounted for the quality of the surface used in the internal roads used by cows: 0 for natural ground, 1 for gravel and 2 for cement/asphalt. The minimum possible score was 0 for farms without foot-baths, hoof trimming and natural ground. The maximum was 6 for farms with foot-baths, frequent hoof trimming and cement/asphalt surface.
5. **Score of mastitis prevention and diagnosis (ScPdMa)**: This was calculated by adding three sub-scores. The first one added values of 1 if the following practices existed: washing the teats before milking, drying the teats before milking, disinfecting the udder after milking, periodically adjusting the pressure of the vacuum pump, applying antibiotics when drying out a cow (maximum value=5). The second sub-score measured the use of tissues or towels to dry the teats before milking, assigning the following values: 0 not use, 1 for shared towels/tissues for several cows, and 2 for individual towels/tissues per cow. The last sub-score measured the intervals between California Mastitis Tests: 0 for never at all, 1 for more than 30, 2 for between 15-30 and 3 for less than 15 days intervals. The thresholds were defined according to the distribution of the variable. The minimum score was 0 for farms without any prevention practice nor diagnosis, while the maximum was 10 for farmers using all the practices with frequent diagnosis.

These scores were also introduced in a factor Analysis to produce three factor scores, of which the rotated factor patterns are shown in Table 7.1. As can be seen, the first factor (FaRepAi) was positively correlated to post-calving treatment management and artificial insemination. The second one (FaLaGy) was positively related to lameness prevention and diagnosis and gynaecological examinations, while factor 3 (FaMas) was related to Mastitis prevention and diagnosis.

Nutritional strategies scores and factors

1. **Number of feeding strata (NuFeSt)**: This variable accounted for the number of strata in which the milking cows were divided for feeding.
2. **Milk/concentrates ratio (RaM/C)**: This was a binomial variable of the milk/concentrate ratio for feeding the milking cows.
3. **Supplementation strategy (ScSup)**: This was calculated by assigning values according to the strategy used: 0 for non-supplementation, 1 for supplementation based on agricultural by-products, 2 for supplementation based on a mixture of agricultural by-products, and concentrates, and 3 for supplementation based only on concentrates.

Similarly, these three variables were introduced into a Factor analysis which produced two new variables (Table 7.1). The first one was related to the use of stratified herds using the milk/concentrate ratio to feed the cows (FaNs), while the second one was positively related to the use of concentrates (FaCon).

Table 7.1. **Rotated factor patterns for managerial supports and reproductive, health and nutritional strategies.**

Variables	Factors						
	Managerial supports		Reproductive and Health management			Nutritional Strategies	
	FaRec	FaTech	FaReAi	FaLagy	Famas	FaNs	FaCon
ScTeAd.	0.139	0.984	-	-	-	-	-
ScReKe	0.851	0.268	-	-	-	-	-
ScReTy	0.915	0.025	-	-	-	-	-
SsGyEx	-	-	0.509	0.714	0.044	-	-
SsPcTr	-	-	0.856	0.193	0.051	-	-
ScAi	-	-	0.847	0.047	0.181	-	-
ScPdmas	-	-	0.149	0.022	0.986	-	-
ScPdLa	-	-	0.006	0.942	0.007	-	-
NuFeSt	-	-	-	-	-	0.861	0.031
ScSup	-	-	-	-	-	0.132	0.986
RaM/C	-	-	-	-	-	0.797	0.212
Eigenvalue	1.782	0.837	2.270	1.115	0.792	1.583	0.830
Difference	0.945	0.457	1.155	0.323	0.331	0.752	0.243
Proportion	0.594	0.279	0.454	0.223	0.158	0.528	0.277
Cumulative	0.594	0.873	0.454	0.677	0.835	0.528	0.804

Quantitative management variables

1. **Fertilisation (N/ha/year, P/ha/year, K/ha/year)**: Included the level of nitrogen, potassium and phosphorus in kg/ha/year in the grazing areas used by the milking cows. They were derived from the amount of inorganic fertiliser used per paddock and the frequency of applications per year.
2. **Stocking rate (Au/ha)**: This was calculated from the milking cows inventories by assigning a value of 1.33 animal units per cow of large breeds (Holsteins, Guernsey, Brown Swiss) or any of their cross with Zebu breeds (Brahaman, Nelore, etc). A value of 1 was given to each small cow breed (Jersey and Zebu). The amount of cows for each breed was calculated from the proportion of breeds in the herd. The final stocking rate was a measure of the animal units per ha in the milking cows area.

3. **Net energy supplemented (NE/cow/day)**: This was a measure of the level of energy supplemented to the milking cows per day. It was calculated from food purchases and from the information of the feeding groups supplementation. The NE_L (Net energy for lactation) was derived from the daily intake of all the feeds used for milking cows and their nutritional composition according to the manufacturers' labels in the case of concentrates, and from an already existing local bromatological database. This variable was expressed in Mcal of NE/cow/day.

Overall factors of management

Once all the scores were calculated and transformed into factors, they, along with the quantitative management variables, were introduced into a general Factor Analysis in order to produce factors (MaFacts) accounting for a large proportion of the variance representing the different dimensions of the management of the farms. These new variables, together with the biographic variables, the profiles and performance variables (explained below), constituted the final database used in the analyses.

Biographic variables and profiles

The biographic variables included farmers' gender (Gen), age (Age), educational level (Edu) (1=none, 2=primary, 3=secondary, 4=technical and 5=universitary) and level of dedication to farming (Dedi) (hours/week). The farmers' profiles (Profs) included Economic objective Profiles (Ep_{1-6}), Familiar objective Profiles (Fp_{1-7}), Personal objective Profiles (Pp_{1-7}), Decision-making approach Profiles (Dp_{1-5}) and Informational Preference Profiles (Ip_{1-9}) (Table 7.2).

Table 7.2. **Objective orientation, decision-making approach and informational preference profiles (from chapters 4, 5, and 6)**

Profiles	n	%	Traits
Ep1	11	12	*Savers, Maximisators-entrepreneurs, Income-ensurers, Less-Quality seekers*
Ep2	20	22	*Investors, Expansionists, Income-ensurers, Quality-seekers*
Ep3	9	10	*Non-maximisators, Pro-family, Expansionists, Income-ensurers*
Ep4	26	29	*Maximizators-entrepreneurs, Intensivists,, Quality-seekers*
Ep5	15	17	*Non-maximisators, Pro-family, Intensivists, Non-income-ensurers, Quality seekers*
Ep6	9	10	*Investors, Mazimisators-entrepreneurs, Expansionists, Income-ensurers*
Pp1	18	20	*Risk-takers, Dedicated innovative*
Pp2	16	18	*Risk averse, Environmentalists, Hard-worker, Humble*
Pp3	12	13	*Environmentalists, Recognised-Hard-worker, Non-dedicated, Traditional*
Pp4	13	14	*Risk-averse, Environmentalists, Humble-Work-minimisators, dedicated innovative*
Pp5	10	11	*Environmentalists, Recognised-Hard-worker, Dedicated- innovative*
Pp6	13	11	*Risk-takers, Non-environmentalists, Work minimisators, Non-innovator*
Pp7	8	9	*Environmentalists, Humble-Work-minimisators, Non-dedicated traditional*
Fp1	18	20	*Non conformists, Non-pro-inheritance, Pro-live-standard improvement*
Fp2	15	17	*Non conformists, Non-pro-inheritance, Non-pro-live-standard improvement*
Fp3	13	14	*Conformists, Non-pro-inheritance*
Fp4	13	14	*Non-conformists, Pro-live-standard improvement*
Fp5	13	14	*Non-pro-inheritance, Non-pro-live-standard improvement*
Fp6	9	10	*Non-conformists, Pro-inheritance, Non-pro-live-standard improvement*
Fp7	9	10	*Conformists, Pro-inheritance, Pro-live-standard improvement*
Dp1	35	39	*Alone*
Dp2	11	12	*Family*
Dp3	15	17	*Alone and shared*
Dp4	16	18	*Balance Alone and Family*
Dp5	14	15	*Alone and delegate*
Ip1	16	18	*Technical advisors Trusters*
Ip2	12	14	*Family trusters*
Ip3	8	9	*Family and Technical advisors trusters*
Ip4	11	12	*Family, Technical advisors and Other farmers trusters*
Ip5	9	10	*Other farmer and Technical Advisors trusters*
Ip6	13	15	*Family, Technical advisors and Commercial Agents trusters*
Ip7	5	6	*Multiple information sources trusters*
Ip8	10	11	*Family, Farm staff and Technical advisors trusters*
Ip9	5	6	*Non-Personal information trusters*

Farm characteristic variables

These variables included: pasture area of the farm in hectares (Area), number of milking cows (Cows), region of farm location (Region) (1= Pacific, 2= North, 3= Central Oriental and 4= Central Occidental), productive orientation of the farm (Orie) (1=specialised dairy farms, 2=dual-purpose farms) and distance of farm from population centres (Dist) (km).

Performance variables

The performance variables measured a productive and an economic dimension of the farm. The productive variables included: the mean of milk yield per cow per day (milk/cow/day) (derived from the total milk yield of the herd per day divided by the number of milking cows), and milk yield per hectare per year (milk/ha/year) measured as the ratio milk/day*365 divided, by Area. The economic variables included margin per cow per day (margin/cow/day*), margin per hectare per year (margin/ha/year), rate of return on working capital, and an efficiency parameter derived from the Stochastic production Frontier Analysis explained in the next section.

Stochastic Frontier Analysis

An efficiency parameter for each farm was calculated using a stochastic production frontier analysis. This analysis yielded a new dependent variable, farm specific technical efficiency. This variable was used in the linear regression analysis described in the next section, which measures the relationship between farmer characteristics and farm performance.

The basic theoretical assumptions underlying these models are as follows: a) output depends on inputs; and b) the production relationship can be conceptualised in terms of a "frontier" defined as the maximum possible output that can be obtained from a

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* Margin represented the difference between total income (Inc) (total milk sold*US$ 0.28) and the costs including feeding, fertilising and hired labour.

given set of inputs. Production frontier models, originally developed by Farrell (1957), have been widely used in the agricultural literature to estimate farm output or productivity (See Battese (1992) for a survey of empirical applications).

The stochastic production frontier model used in this study is a standard Cobb-Douglas function and was estimated using maximum likelihood. The properties of this function are: a) it is reasonably close accordance with economic theory, and b) an intrinsic linearity with respect to the parameters to be estimated (Moock, 1981). In this model y represents the maximum possible output for a given set of inputs This model has 4 inputs labelled x_i for i=1,..,4 and 3 dummy variables, indicated by d_i for i=1,...,3. More formally:

$$y = \alpha + \beta_1 x_1 + \beta_2 x_2 + \beta_3 x_3 + \beta_4 d_1 + \beta_5 d_2 + \beta_6 d_3 + \beta_7 d_4 - u + \varepsilon$$

Where

y = log of milk yield per hectare per day

x_1 = log of total purchases of feed and fertilisers per hectare per day

x_2 = log of cows per hectare

x_3 = log of labour, defined as the total number of family and hired labourers on the farm

$d_{1,2,3}$ = regional dummy variables, representing farming regions Pacific, North and Central Occidental and Central Oriental (missing category), respectively.

d_4 = specialised breed, defined as 1 if the herd is comprised either entirely of or a mixture of specialised cows (i.e. Holsteins and Jerseys) and 0 otherwise

u = is error, defined as inefficiency, and measured as the distance below the logged frontier

ε = standard measurement/mis-specification error

Both, the dependent variable and the inputs were scaled to land units in order to represent efficiency in terms of intensification i.e. input per land unit, as land availability is one of the biggest production constraints in the country. This is because its cost and

the environmental pressure against expansion of the agricultural frontier. Therefore one farm is considered to be more efficient as it is able to produced more in less area.

In this study, the dependent variable was efficiency rather than the inefficiency measure directly estimated by this model. Efficiency measures for 88 farms were calculated by simply taking the exponential of the negative or anti-log of u (i.e. inefficiency). Efficiency measures are more intuitive indicators of farm output than are measures of inefficiency since they can be expressed as a number between 0 and 1. Thus, a value of 0.8, for example, indicates a farm is 80% efficient (i.e. only producing 80% of what it could if it were fully efficient).

7.2.2 Statistical analyses

The impact of biographical variables and profiles on management practices and farm performance

General linear models

A series of analyses of variance using the General Linear Model (SAS, 1994) were used to quantify the effect of the biographical variables and the profiles on the management factors. Other analyses were also performed in order to investigate the effect of the management factors on the performance variables (productive and economic). Finally, relationships between the biographical and the profiles variable on performance

variables were measured directly. The model descriptions were:

MaFacts= u+ Region + Orie + Gen + Profs + coArea + coCows + coAge + coEdu + coDedi + coDist + coInc + ε

PerVa = u+ Region + Orie + Gen + MaFacts + coArea + coCows + coAge + coEdu + coDedi + coDist + ε

PerVa = u + Region + Orie + Gen +Profs + coArea + coCows + coAge + coEdu + coDedi + covDist + ε

where PerVa= performance variables, u= population mean, Profs= Profiles, Mafacts= Management factors, co=covariates and ε= sampling error.

Since the profiles were actually groups of farmers sharing similar scores for factors representing different dimension of objectives, decision-making approaches and informational preferences, these original factors were used as explanatory variables in a series of multiple regression analyses. In this way it was possible to find out which dimension defining de profiles accounted for the largest variation in the management factor and performance variables and therefore the underlying variables that have more impact on management and performance.

In all the variance analyses, a stepwise procedure was followed. This process started with univariate models, which measured all the variables alone against the dependent variables. The variable producing the smallest residual was selected, and all the bivariate models including this variable were then tested. The combination producing the smallest residual was kept and all trivariate models including this combination were tested, and so on. The process stopped when any of the remaining variables (not yet included in the model) had a significant effect at the chosen level $P<0.15$. This level was selected by taking into account the size of the sample and the exploratory nature of the analyses. A Sum of Squares Type I was used to test the null hypotheses that the biographic and the profiles had no effects on the management and the performance of the farm. Once the best model was selected, the Least Square Means (Lsm) of each significant categorical variable (e.g. profiles) and the slopes for the covariates (e.g. age) were calculated. Since the matrices used were not balanced (different number of observation in each categorical variable), the Lsm means were calculated to infer the arithmetic means as if the models were balanced.

7.3 Results and discussion

7.3.1 Overall factors of management

Table 7.3 shows the rotated factors for the overall management practices. Mafact1 was highly correlated with the fertilisation level of the area of milking cows. Au/ha was also positively related to this factor. However the latter was more strongly related to MaFact3. Therefore this factor was labelled as 'Pasture Management'.

Table 7.3. **Rotated factor patterns of general management**

Variables	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5
N/ha/year	0.91738	0.14062	0.06416	-0.07459	0.08949
P/ha/year	0.96918	-0.01283	0.04678	-0.00631	0.03998
K/ha/year	0.96933	0.03305	0.09182	0.03540	0.02760
Ua/ha	0.46421	0.06912	0.57100	-0.29237	-0.08643
FaRec	0.01882	0.50888	0.56901	0.24547	-0.19158
FaTech	-0.09797	0.65253	-0.32932	0.08453	0.39217
FaRepAi	0.13414	0.83366	0.25501	-0.12094	-0.04710
FaLaGy	-0.03564	0.09050	0.16720	0.93812	-0.01832
FaMas	0.11142	-0.00029	0.12133	-0.01603	0.90206
FaNs	0.04926	0.86436	0.02447	0.11978	-0.05845
FaCon	-0.01286	-0.08693	0.73781	0.32461	0.18605
NE/cow/day	0.17357	0.51611	0.59288	0.01131	0.22004
Eigenvalue	3.6238	2.4240	1.4581	1.0881	0.9140
Difference	1.1999	0.9659	0.3700	0.1741	0.1696
Proportion	0.3020	0.2020	0.1215	0.0907	0.0762
Cumulative	0.3020	0.5040	0.6255	0.7162	0.7923

MaFact2 had high loading coefficients in FaNs, FaRepAi, FaTech and EN/cow/day showing that this factor represented the nutritional strategies in terms of the number of strata in which the cows were divided for feeding and use of the milk/concentrate ratio. It was also related to some reproductive practices such as post-calving treatments (ScPcTr) and the percentage of the matings made by artificial insemination (ScAi). The

level of technical advising was highly correlated with this factor. This result shows a close relation between farmers using more reproductive and nutritional technologies and the level of technical advising. This suggests the influence of the latter on the former. Although this factor was related to EN/cow/day and FaRec (record keeping), the biggest loading of these variables were in Mafact3. Therefore this factor was labelled as 'Technical Advising, reproductive and nutritional strategy'.

MaFact3 is positively related to the supplementation strategy using concentrates (FaCon) and the energetic supplementation level (EN/cow/day), showing the high relationship between this two variables. It was also related to the stocking rate. This indicates that those farmers using more concentrates and therefore high energetic intakes, were able to increase the stocking rate due to the reduction in pasture intake, or that those farmers using higher level of concentrates tended to be more intensivist. Finally, record keeping (FaRec) is also positively related of this factor. It was labelled Supplementation with concentrates, record keeping and stocking rate.

MaFact4 and Mafact5 are positively correlated to FaLaGy and FaMas and thus represent the Health management aspects of the farms. The former represents the prevention and diagnosis of lameness problems and gynaecological examinations, and the former, the prevention and diagnosis of mastitis.

7.3.2 The impact of biographical variables and profiles on management

Table 7.4 shows the analysis of variance for the impact of biographical variables and profiles on the management factors. This table shows how pasture management, represented by MaFact1, was significantly influenced by the Area, the Decision making approach Profiles and the Educational level of the farmers. It explained 32% of the variance. For Area, its slope estimate was negative due to the higher fertilisation costs as area increases and the extensivist management orientation that is expected in bigger farms. With respect to the Edu, its slope was positive showing that farmers with higher education tend to manage pasture with more fertiliser and therefore used a higher stocking rate.

Table 7.4. **Variance analysis of the effect of farmers' profiles on the management factor.**

Management factors	Source	DF	Sum of Squares	Mean Square	F Value	Pr > F	r^2	slopes
MaFact1 Pasture management	Model	6	7.351	1.225	6.22	0.000	0.32	
	Area	1	2.789	2.789	14.15	0.000		-0.004
	Dp	4	3.456	0.864	4.39	0.003		
	Edu	1	1.107	1.107	5.62	0.020		0.0884
	Error	80	15.761	0.197				
	Total	86	23.112					
MaFact2 Technical advising, reproductive and nutritional strategy	Model	21	52.838	2.516	4.73	0.000	0.60	
	Region	3	29.280	9.760	18.34	0.000		
	Ip	8	13.294	1.662	3.12	0.005		
	Ep	5	5.155	1.031	1.94	0.100		
	Dp	4	3.872	0.968	1.82	0.136		
	Edu	1	1.237	1.237	2.32	0.132		0.1259
	Error	66	35.124	0.532				
	Total	87	87.962					
MaFact3 Supplementation on concentrates, record keeping and stocking rate	Model	2	37.880	18.940	33.42	0.000	0.44	
	Orie	1	35.594	35.594	62.80	0.000		
	Age	1	2.286	2.286	4.03	0.048		-0.013
	Error	85	48.178	0.567				
	Total	87	86.058					
MaFact4 Control of Lameness problems and gynaecological examinations	Model	9	41.940	4.660	8.19	0.000	0.49	
	Region	3	24.543	8.181	14.37	0.000		
	Dp	4	10.686	2.671	4.69	0.002		
	Area	1	4.662	4.662	8.19	0.005		0.0050
	Edu	1	2.050	2.050	3.60	0.061		0.1405
	Error	78	44.403	0.569				
	Total	87	86.343					
MaFact5 Control of mastitis	Model	4	17.177	4.294	5.28	0.001	0.20	
	Orie	1	8.845	8.845	10.88	0.001		
	Region	3	8.332	2.777	3.42	0.021		
	Error	83	67.480	0.813				
	Total	87	84.656					

This could be an effect of their better understanding of the impact of using fertilisers on the performance of the farm in the long term. Dp was found to explain the biggest proportion of the variation. Figure 7.1 shows the Lsm of the MaFact1 by the Dp

categories. It is clear that farmers belonging to profile 3 (Alone and Share) had the biggest mean, showing that the fact of sharing decisions had a positive effect on the level of fertilisation. In chapter 5 it was demonstrated that the majority of the shared decisions were made by the farmer in conjunction with technical advisors and the farm staff. This shows that those farmers open to such influence increase fertilisation levels as consequence of technical and practical knowledge of its impact on the performance of the farm.

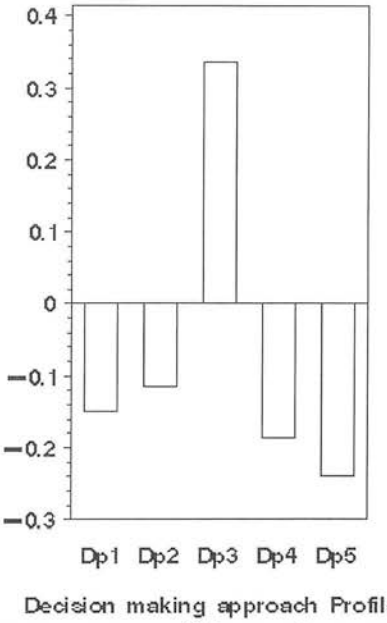

Figure 7.1. Least squares means of the pasture management factor (MaFact1) by the Decision-making approach Profiles.

Figure 7.1 also shows that farmers belonging to Dp5 (Alone and Delegate approach) had the lowest pasture management score. This finding suggests that, regardless of the educational level, delegation per se had a negative impact on fertilisation management. It could be hypothesised that those people to whom decisions are delegated tend to reduce the effort (as their own objective) thereby reducing the number of practices which would not have an immediate effect on production i.e. fertilisation.

A comparison of the Lsm indicated that there were no significant differences among Dp1, Dp2, Dp4 and Dp5. This suggests that there are also negative effects for pasture management in respect to decision-making approaches in which the family plays an

important role. It may be that this result is less due to a direct negative effect of the family on management practices, as it is to more isolated farmers, who have less access to other people with practical and technical knowledge of the benefits of fertilising practice. Table 7.5 show the negative slopes for familiar decision-making and delegation and positive effect of sharing decisions.

Table 7.5. Estimates of the profiles' slopes (as continuous variables) in the multivariate analyses of their effect on the management factors

Manag. factors	Profiles	Factors	Main traits of the original factors	Slopes	Stand. error	Pr> F
MaFact1	Decision making approach	Dpfa1	familiar	-0.0200	0.0515	0.699
		Dpfa2	share	0.1960	0.0538	0.001
		Dpfa3	Delegate	-0.0829	0.0511	0.109
MaFact2	Information preferences	Ipfa1	Family	-0.3085	0.0829	0.000
		Ipfa2	Other farmers	0.0977	0.0830	0.243
		Ipfa3	Farm staff	0.2558	0.0833	0.003
		Ipfa4	Technical advisors	0.5185	0.0831	0.000
		Ipfa5	Commercial Agents	0.0871	0.0830	0.297
	Economic objectives	Epfa1	pro investments	-0.1911	0.1001	0.060
		Epfa2	maximisation	-0.3343	0.1033	0.002
		Epfa3	satisfactory income	-0.1324	0.1003	0.190
	Decision making approach	Dpfa1	familiar	-0.1632	0.0996	0.105
		Dpfa2	share	0.3598	0.1042	0.001
		Dpfa3	Delegate	0.1125	0.0990	0.259
MaFact4	Decision making approach	Dpfa1	familiar	-0.0035	0.1076	0.974
		Dpfa2	share	-0.0071	0.1126	0.950
		Dpfa3	Delegate	0.0451	0.1070	0.674
Milk yield/cow/ day	Information preferences	Ipfa1	Family	-0.6055	0.4593	0.1912
		Ipfa2	Other farmers	0.5700	0.4616	0.2206
		Ipfa3	Farm staff	0.6905	0.4661	0.1425
		Ipfa4	Technical advisors	0.8914	0.4870	0.0710
		Ipfa5	Commercial	0.4010	0.4542	0.3800
Margin cow/day	Information preferences	Ipfa1	Family	0.0155	0.0885	0.8610
		Ipfa2	Other farmers	0.1084	0.0889	0.2265
		Ipfa3	Farm staff	0.0991	0.0898	0.2729
		Ipfa4	Technical advisors	0.1370	0.0938	0.1480
		Ipfa5	Commercial agents	0.0208	0.0875	0.8126

The MaFact2, which was related to the level of technical advice and technologies related to reproductive management and nutritional strategies, was significantly effected by Region, Ip, Ep, Dp and Edu (r^2=0.60). It was in respect to this management factor that the decision-profiles had the biggest impact. Region was the variable explaining the biggest proportion of the variation, showing that environmental conditions are shifting the management represented by this factor. Farms located in the Pacific region (Dry region) and North (humid region) had the lowest least squared means while farms located in the Central Oriental and Central Occidental regions (highlands) had the biggest. The Lsm of the latter region, in particular, was higher and significantly different from the rest of the regions. It is a reflect of more specialised dairy farms with more experienced farmers found in that region. The fact that the effect of the production orientation (Orie) was not significant can be explained by a confounding effect with region. The productive orientation is mostly driven by the environment in which the farm is located, so that farmers in the Central region of the country tend to be specialised while farmers in the Pacific region tend to have dual-purpose production orientation. This difference in environment-production orientation has an impact on the feasibility and necessity of adopting the management practices represented in the MaFact2, such as herd strata, milk/concentrate ratio, reproductive treatments and artificial insemination and technical advice. Here remoteness of the farm, accounted by the Region (Distance was not significant), is playing an important role in the availability of technical advisors and the incremental cost of their services. Solano *et al* (2000) observed a close negative relationship between the remoteness of the farms and the use of technologies and technical advising in a study of Bolivian farmers.

Once the regional variations were taken into account, the profiles, and once again the educational level, had significant impacts on MaFact2. Figure 7.2 shows how farmers who have a high preference towards family members as information sources (Ip2, Ip3 Ip4 and Ip8) and those farmers without any preference towards personal informational sources (Ip9) obtained the lowest Lsm. Those farmers with multiple information sources (Ip7), especially from technical advisors and Commercial Agents (Ip5 and Ip6), had the largest Lsm. This provides evidence of the impact of the openness of the farmers to the

use of technologies. This finding was also found in Bolivian dairy farmers by Solano *et al* (2000). The slopes of the original factors on MaFact2 (Table 7.5) show that the preference towards the family, Technical advisors and farm staff were the underlying variables reducing or increasing the level of the MaFact2, respectively. Technical advisors had the biggest impact.

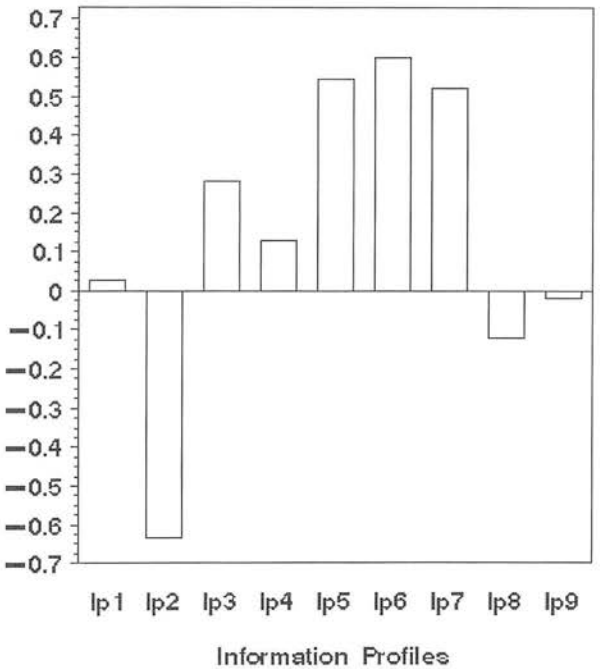

Figure 7.2. Least squares means of Technical advising, reproductive and nutritional strategy factor (MaFact2) by the Informational Profiles.

It is important to note that since MaFact2 was positively related to the actual technical advice used by the farmer, the necessity of determining the cause and effect nature of the relation arises. The questions are: is it the preference towards technical advisors that makes the farmers recruit them, and is it the higher level of the MaFact2 a consequence of the technicians recommendations? Or, is it the presence of technical advisors that shift the farmers' preference towards them? Finally, is it an effect of the technicians? Or an effect of the openness of the farmer? Or a combination of them? It seems to be more likely that farmers' positive perceptions of technical advisors might occur first as a consequence of the educational level of the farmer (well educated farmers trust other well educated people). Farmers in turn recruit advisors who will provide knowledge

through recommendations that, due to his/her openness and trust, are adopted. In other words, the causality is determined by a combination of farmers' managerial capacity in terms of openness and educational level (the former is probably a consequence of the latter) and the advice from the technicians. It is important to note that in the Costa Rican case, technical advice is mostly privately procured.

The Economic objective profiles were found to affect the level of MacFact2 used. The Lsm in Figure 7.3 indicates that the maximizator-entrepreneur farmers (Ep4 and Ep6) had the highest level of MacFact2, while farmers belonging to the non-maximisation and pro-familiar orientation (Ep3 and Ep5) had the lowest ones. It is important to note that the two groups differ significantly in their mean comparisons. This result shows how the objective orientation towards maximisation of monetary outcomes and investing in the farm (Ep6) are translated into management practices.

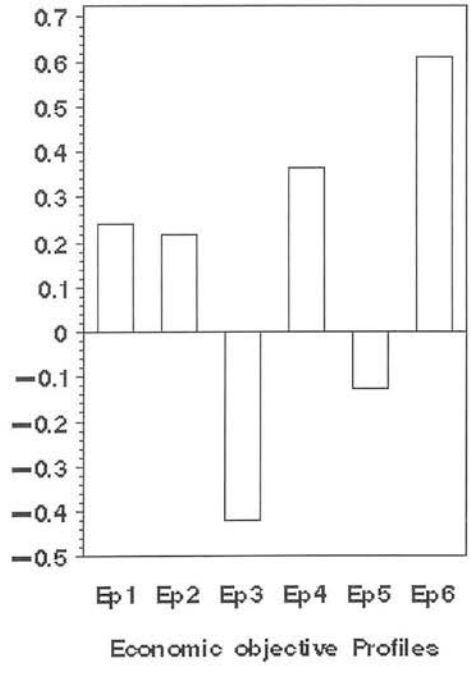

Figure 7.3. Least squares means of the Technical advising, reproductive and nutritional strategy factor (MaFact2) by the Economic objective Profiles

The slopes* in Table 7.5 show that the three original factors that defined the profiles had positive effects on the level of MaFact2. The slope of Epfa2 was the steepest, showing that the orientation towards obtaining the maximising income and revenue, as opposed to saving money for the family (a monetary objective representing familial welfare), are the objectives more strongly affecting the MaFact2. Again, the orientation towards the family, this time in terms of objectives, seems to constrain the use of technical advice and technologies in reproduction and nutrition.

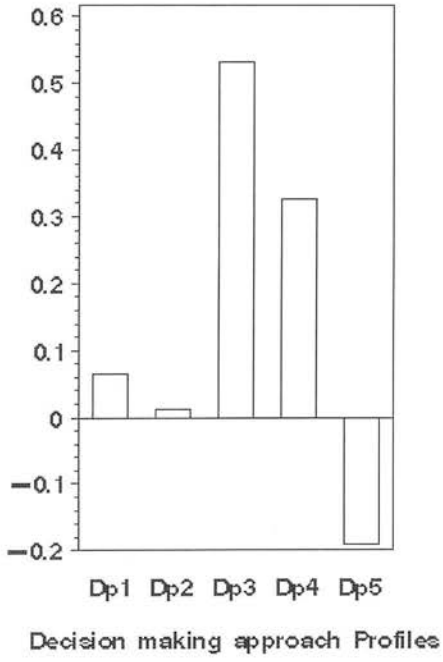

Figure 7.4. Least squares means of the Technical advising, reproductive and nutritional strategy factor (MaFact2) by the Decision making approach Profiles

The decision-making approach affected the level of Mafact2 in the same way it did in MaFact1. Those farmers with an approach towards decisions made alone and shared (Dp3) had the biggest level of MaFact2 (Figure 7.4), while those farmers who delegated more decisions (Dp5) had the lowest level. Is should be stressed that significant

* In the case of the economic objectives, slopes should be interpreted in an opposite way than the sign indicates, see chapter section 4.3.2 chapter 4 for detail.

differences were only observed between these two profiles. These result show the impact of the influence of other people on the decision-making process, where decision-making units that use other people's experience such as technical advisors and farm staff (that frequently include family members) tend to use more technologies, product of their own technical and practical knowledge. When decisions are delegated more frequently, the decision-making unit is substantially modified, shifting the objectives (probably towards effort reduction) thereby diminishing the use of technologies. This is evidence in favour of the hypothesis that, if delegation of decisions is frequent, or the farm staff is not actively involved in the decision-making process, a farmer can acknowledge the usefulness of different technologies. However the farm staff, in view of their own objectives, will reject them since more work and responsibilities are involved in implementing them.

The educational level also affected the level of MaFact2. The slope (Table 7.4) shows a positive effect demonstrating that well educated farmers tend to have a higher level of MaFact2. It is important to note that educational level was significantly related to the original factors used to define the profiles. Therefore its impact should be considered as double; one in partially defining the profiles and another directly influencing in the management of the farm.

MaFact3, which was related to the level of use of concentrates, supplementation, record keeping and stocking rate, was not affected by any of the profiles. It was only affected by the production orientation, where dual-purpose farms tended to have very low scores. Concentrates have been more extensively used in specialised dairy farms using high genetic potential cows. In dual-purpose farms, feeding is traditionally based on agricultural by-products. As explained before, the stocking rate seems to be an effect of the use of concentrates and its impact on the intake of pasture. Since the dual-purpose farms use less concentrates and have bigger pasture areas, it is not surprising that this type of farm obtained lower scores on this management factor. Age had a significant effect. The use of more sophisticated record keeping systems, such as computerised management information systems, is more likely to be adopted by a younger farmer than an older one. This could be explained as consequence of a negative attitude of older

farmers towards the "difficulty" of learning how to use computers and that younger farmers has grown up with and studied using them. These two variables accounted for 44% of the variation in this management factor.

The control of lameness problems and the level of gynaecological examinations (MaFact4) were significantly affected by Region, the decision making approach profiles, pasture area and education. The coefficient of determination (r^2) in Table 7.4 showed that 49% of the variance was accounted for by these variables. The North Region obtained the highest Lsm while the Pacific, Central Oriental and Central Occidental regions obtained the lowest score and had no significant differences among the last three regions. No straightforward explanation is available in terms of gynaecological examinations, since this practice is relatively generalised throughout the regions (except in the Pacific). However these regional differences can be attributed to lameness control practices in the North region which is a humid environment and the incidence of this problems is higher than in other regions. Therefore controls to prevent this disease are more likely to be found there. Dp again had a significant effect on the level of this management factor.

Figure 7.5 shows that once again those farmers with a decision making approach in favour of sharing decisions had higher scores. The delegation approach had a positive effect. This could be explained by delegation in favour of technical advisors such as veterinarians. In chapter 5 is was demonstrated that some technical decisions related to health and reproduction are often delegated to this type of technical advisor. Statistical differences were only found between these two profiles and the rest of decision making approach profiles. The slopes in Table 7.5 show that none of the slopes of Dp's original factors had a significant impact on MaFact4 score. This demonstrated that Dp is only significant when it is considered together with the regional variable.

Area and Edu were significant variables affecting MaFact4. One explanation may lie in the relation between pasture area and number of cows. As the number of cows increases, the need for lameness and reproductive controls increases. Another explanation could be that as the farm size increases, cows need to walk more and

lameness problems increase. Once again, educational level seems to positively affect the use of these health practices.

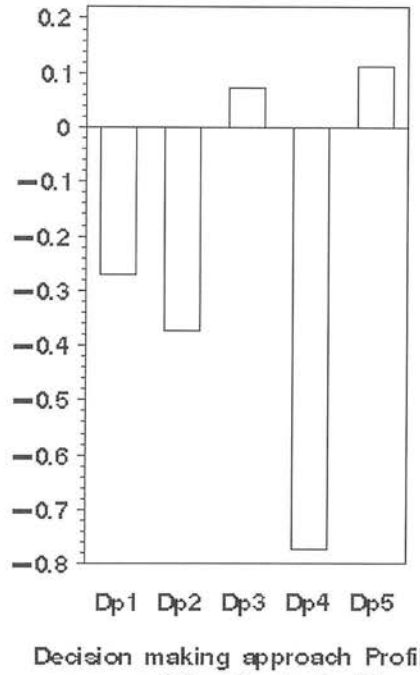

Figure 7.5. Least squares means of the Control of lameness problems and gynaecological examinations s factor (MaFact4) by the Decision making Profiles

Finally, Orie and Region affected MaFact5 significantly but explained only 20% of the variation. This can be easily explained by the lower incidence of mastitis in dual-purpose farms due to the practice of calf suckling which reduce the incidence of this disease. The Lsm for the regions did not give any relevant information for explaining the differences among them. All the regions had negative Lsm except the Pacific region. There is not an explanation for this finding.

In general terms, it could be said that a combination of region, farm characteristics, some biographical variables and decision-making profiles were able to explain important proportions of the management variations, especially as measured in Mafact2 (r^2=60%). Among the biographical variables, the educational level and the Dp, Ip from the point of view of the profiles, were the variables more strongly determining the management. This combination of variables defined the managerial capacity of the farmers that in turn,

depending on the environment in which his/her farm is located, defined the management practices of the farm from the technologies available from his/her trusted knowledge systems.

From the point of view of the technology transfer activities, these findings demonstrate that the target for extension activities should be wider, taking into account all the spectrum of actors in both decision-making and information sources. Different strategies should be designed for farmers with different level of education, openness, and decentralisation of decision-making. Special efforts should be directed towards those who have preference towards family members as information sources and decision-making actors, in order to include the whole family in the extension process. Finally, the impact of region and productive orientation shows that the relevancy, necessity and feasibility of certain technologies should be evaluated in the context of the conditions in which the farm and farmer are located.

7.3.3 The impact of management on performance

Tables 7.6 shows the analyses of variance of the influence of the farm management factors on a series of productive and economical performance variables. This was carried out to obtain evidence of the effects of the biographical and profiles variables on farm's performance via their relation with the management. It would be expected that any farmer characteristic would not affect the performance of the farm unless it affects management of the farm resources. The extent to which the farmer characteristics directly affect the performance will be constrained by the environment in which the farm is located. Nevertheless some attempts to relate farmers' characteristics and the final outcomes were also made.

Table 7.6. **Variance analysis of the effect of management factors on performance**

Performance variables	Source	DF	Sum of Squares	Mean Square	F Value	Pr > F	r^2	slopes
Milk yield/cow/day	Model	6	1674.766	279.128	20.95	0.000	0.60	
	Region	3	887.816	295.939	22.21	0.000		
	MaFact3	1	315.990	315.990	23.72	0.000		2.3
	MaFact2	1	367.562	367.562	27.59	0.000		2.5
	MaFact5	1	103.398	103.398	7.76	0.007		1.1
	Error	82	1092.518	13.323				
	Total	88	2767.284					
Milk yield/ha/year	Model	5	3223406569	644681314	37.29	0.000	0.69	
	MaFact1	1	1448339953	1448339953	83.77	0.000		3812
	MaFact3	1	1215738796	1215738796	70.32	0.000		3305
	MaFact4	1	294951317	294951317	17.06	0.000		-1620
	MaFact2	1	209548934	209548934	12.12	0.001		1570
	Area	1	54827569	54827569	3.17	0.079		-17
	Error	83	1435049137	17289749				
	Total	88	4658455706					
Margin cow/day	Model	6	43.389	7.232	11.91	0.000	0.46	
	Region	3	28.535	9.512	15.67	0.000		
	Orie	1	10.103	10.103	16.65	0.000		
	MaFact2	1	2.601	2.601	4.28	0.042		0.238
	MaFact3	1	2.151	2.151	3.54	0.063		0.207
	Error	82	49.772	0.607				
	Total	88	93.161					
Margin ha/year	Model	8	598.582	74.823	15.81	0.000	0.61	
	MaFact3	1	271.023	271.023	57.28	0.000		1.557
	MaFact1	1	178.318	178.318	37.69	0.000		1.156
	Region	3	84.985	28.328	5.99	0.001		
	Area	1	28.819	28.819	6.09	0.016		-0.010
	MaFact2	1	20.320	20.320	4.29	0.042		0.589
	MaFact4	1	15.117	15.117	3.19	0.078		-0.531
	Error	80	378.534	4.732				
	Total	88	977.116					
rate of return on working capital	Model	2	2309.032	1154.516	4.33	0.016	0.09	
	MaFact3	1	1211.934	1211.934	4.54	0.036		-3.369
	ED	1	1097.098	1097.098	4.11	0.046		-2.560
	Error	86	22932.696	266.659				
	Total	88	25241.728					

These analyses demonstrated that in general all the management factors affected the performance variables. However their relative importance changed throughout. For example, MaFact1 (pasture management) was significantly important in both milk/ha/year and the margin/ha/year but not important for milk/cow/day nor margin/cow/day. Since this factor was closely related to fertilisation, and slightly so with stocking rate, it shows that the higher the fertilisation regime, the higher the stocking rate and probably, the better nutrition and therefore the more productivity and margin per hectare. The MaFact2 was a determining factor in all the variables except the rate of return on working capital. For milk/cow/day and the margin/cow/day its importance was larger than MaFact3, showing that the combination of reproductive and nutritional strategies (more strategy rather than amount of supplementation) had a positive impact on the performance of the farm. It is important to recall that MaFact2 was also positively related to the actual level of technical advice showing an indirect impact of technicians on the productive and economical performance of the farm.

MaFact3 also had impacts on milk/cow/day and margin/cow/day but was more significant on milk/ha/year and margin/ha/year due to its positive relation with the amount of supplementation and the use of concentrates (rather than by-products). This supplementation had a double affect. The first one by increasing the milk yield and the second by reducing the pasture intake, thereby giving the farmer the opportunity to increase the stocking rate. It is important to point out that this factor had a negative impact on rate of return on working capital due to the higher costs involved in using concentrates rather than agricultural by-products.

The effect of MaFact4 was significant on the milk/ha/year and margin/ha/year. There is no straightforward explanation for this finding except, perhaps, for slight a negative relationship of this factor and the stocking rate (Table 7.4). MaFact5 only had a positive impact on milk/cow/day, showing that mastitis controls had positive impacts on productivity.

Other variables like Region, Area, Orie and Edu, also had significant effects. Region had a significant effect on milk and margin/cow/day. Area had a negative impact milk and margin/ha/year and the educational level only had an impact on the rate of return of

working capital. The slope of this covariate shows that the higher the educational level the lower the rate of return on working capital. It means that farmers manipulated the farm towards higher cash flows rather than to obtain revenue which is a measure of the percentage of returns over the expenditure on working capital. The use of concentrates, for instance, increases the milk yield and margin/cow/day (as cash) but reduce the rate due to the higher cost this input.

These results show an indirect effect of the biographical variables and profiles on the performance of the farm through their effect of management. Although direct relationships between these farmers' variables on performance may exist, the cause effect relation is by nature indirect. It means that no effect on performance will occur unless an effect on management takes place. Since the latter relationship have been already demonstrated, now its is possible to test the hypothesis of direct effects of the profiles and biographical variables on performance as an attempt to prove the impact of these farmer's variables in the more straightforward way.

7.3.4 The impact of biographical variables and profiles on performance

Looking at the direct impact of farmers' characteristics on performance, only the informational profiles had a significant effect on milk/cow/day and margin/cow/day (Table 7.7). For the former, the probability was only 0.13. However, as discussed earlier, due to the size of the sample and the exploratory aim of the variance analyses, a less strict approach for the significance threshold has been taken. Figures 7.6 and 7.7 show very similar patterns, indicating that these two variables increased as information sources (many sources) and the importance of the technical advisors increased. It should be noted that Ip1, although it had a relatively high preference towards the technicians, its Lsm are significantly lower than for Ip7. This means that it is not only the level of openness towards this information source, but a combination of other sources, and especially multiple sources as in the case of Ip7. The Lsm were also significantly lower for Ip8 and Ip9. Farmers in the latter group were not open to any source of information. The mean comparisons showed that Ip1, Ip2, Ip3, Ip8 and Ip9 were significantly lower

than Ip7 for milk yield. Ip1, Ip2 were lower than Ip7, and Ip9 was lower than all the categories except Ip1 and Ip2.

Table 7.7. Variance analysis of the effect of farmers' profiles on performance

Performance variables	Source	DF	Sum of Squares	Mean Square	F Value	Pr > F	r^2
Milk yield/cow/day	Model	12	1466.95	122.25	7.19	0.000	0.54
	Ori	1	848.80	848.80	49.96	0.000	
	Region	3	396.43	132.14	7.78	0.000	
	Ip	8	221.71	27.71	1.63	0.130	
	Error	75	1274.34	16.99			
	Corrected	87	2741.29				
Margin cow/day	Model	12	47.60	3.97	6.84	0.000	0.52
	Region	3	27.93	9.31	16.06	0.000	
	Orie	1	10.31	10.31	17.79	0.000	
	Ip	8	9.36	1.17	2.02	0.056	
	Error	75	43.48	0.58			
	Corrected	87	91.08				

Table 7.5 shows the impact of the original factors (used to cluster the farms into the information profiles) on milk yield/cow/day and the margin/cow/day. It can be seen that for milk/cow/day the preference towards technical advisors, represented by Ipfa4, had the biggest impact, followed by the farm staff, both with positive slopes. No other relation could be suggested due to the lower probabilities. However the preference towards the family had a negative slope. In terms of margin per cow, none of the factors seemed to affect these variables, except a for a slight tendency in favour of technical advisors. This is evidence that the impact of the informational profile is caused by a combination of information sources rather than a single one.

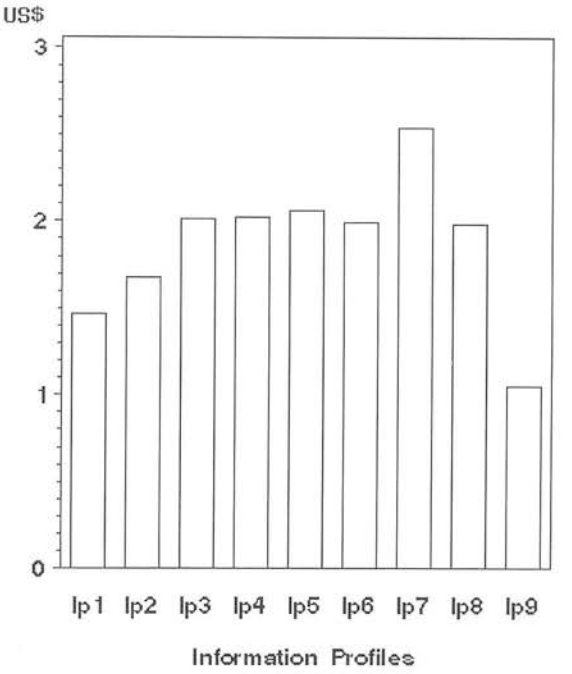

Figure 7.6. **Least squares means of milk/cow/day by the Information Profiles**

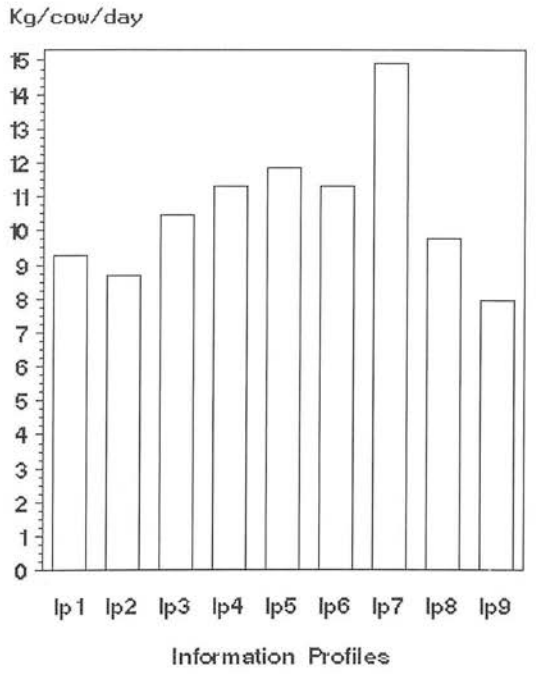

Figure 7.7. **Least squares means of margin/cow/day by the Information Profiles**

In respect to efficiency, Table 7.8 demonstrates the Pacific and North regions were less efficient than Central Occidental (missing category) and Central Oriental. However the coefficient for the latter region is not significant showing no differences between the farms located in the central part of the country. This effect should be interpreted by differences caused by environmental conditions that constrain efficiency. Soil fertility, pasture quality and disease incidence are related to region. The number of cows per hectare showed the largest coefficient demonstrating that the more cows per hectare, the more efficient the farm. It is easily explained in the fact that the response variable is a measurement of the productivity scaled to land. The impact of purchase inputs had the expected positive coefficient showing that the more concentrates and fertilisation were purchased, the more efficient the farm is. It was an effect on production at cow level, a reduction of pasture intake (due to the substitution rate between concentrates and pasture, as demonstrated before) and the subsequent increment in the stocking rate and therefore productivity per unit of land. The amount of labour did not affect efficiency. It could be explained by the small variation in the amount of hired and familiar labour found in the population (see chapter 3).

The value of Lambda demonstrates that the one-sided error was dominated by the random noisy and in less degree by the inefficiency component. The sigma coefficient is an estimated of the standard deviation of the error term in the frontier model.

Table 7.8. Coefficient estimates for the Frontier model

Parameter	Coefficient	Standard error	beta/standard error	P>z
Constant	2.7889	0.1747	15.9640	0.0000
Pacific	-0.2449	0.1492	-1.6420	0.1007
North	-0.2889	0.1081	-2.6730	0.0075
Central Oriental	0.1663	1.1712	0.0970	0.9226
Cows/ha	0.9153	0.0670	13.6650	0.0000
Purchases/ha	0.1145	0.0199	5.7470	0.0000
Labor/ha	0.1050	0.1311	0.3370	0.7358
Breed	0.2310	0.0864	2.6740	0.0075
Lambda	1.1100	0.8981	1.2360	0.2165
Sigma	0.3596	0.0711	5.0560	0.0000

The impact of breed demonstrated that those herds with mixture of non specialised breeds (mostly dual purpose farms) were less efficient than herds with specialised breed. That was expected since the beef production of the farms was not taken into account into the analysis. However the introduction of the breed variable into the model explained this difference in output per hectare per day.

Figure 7.8 shows that the majority of farms are located between 70 and 80% of efficiency and that a very small proportion of them are near to the maximum outputs. In general terms this result demonstrates that the variation among the farmers is very small (coefficient of variation = 8.8%) and that increments in efficiency are still feasible in these farms. The small variations in this parameter could be explained by the bias in the sample used in this study. All farmers sold the milk to dairy companies and therefore they have similar market conditions and the majority of them are constrained by milk quotas* that lead to intensification processes such as producing more milk with less cows is less area.

Non significant effects of any of the biographical variables or the profiles on efficiency were found. This shows that once the variance of region, input, cows, breed and purchases are taken into account, the managerial capacity variables are not important in explaining the inefficiency of the farm. Several factors should be taken into account to interpret this result. Firstly that the farmer's characteristics might have an effect through the input allocation (as demonstrated in the 7.3.2). Secondly, the introduction of control variables such as region and genetic patterns of the herd accounted for much of the variation due to the farmer's characteristics. Thirdly, the response variable was strongly affected by variables such as number of cows and land which were determined by some economic and capital constraints rather than the farmer's characteristics. Fourthly, the sample size, although representative, is not big enough to obtain significance differences.

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* although they had no effect at the time of the study, due to export markets

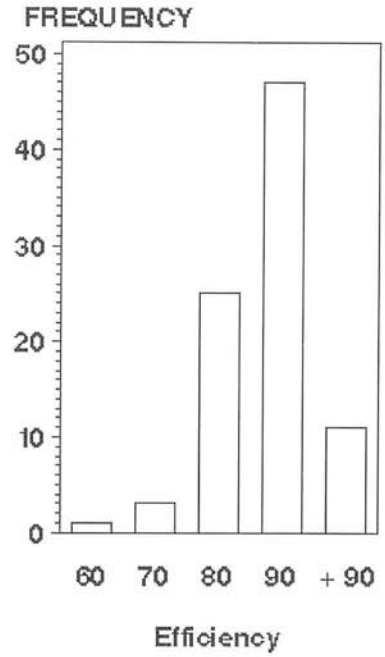

Figure 7.8. Distribution of frequencies of the efficiency parameter of Costa Rican dairy farm

7.4 Concluding remarks

A combination of region, pasture area, productive orientation, age, educational level and decision-making profiles were able to explain a considerable proportion of the variation in the management practices.

The decision-making approach profiles were the ones that had the most significant effect on management factors. However the economic objective and the informational profiles also accounted for a significant proportion of the management factor MaFact2. The impact of the latter was the largest observed of any of the profiles on any of the management factors.

Those farmers with a decision-making profile towards sharing decisions, those farmers with an entrepreneurial profit maximising economic orientation and those with

informational preference towards multiple sources, especially from technical advisors, obtained the highest level in the management factors.

Regardless of the profiles, the educational level also affected positively the majority of management factors, while age affected negatively only the factors related to supplementation with concentrates, record keeping and stocking rate.

From the point of view of farm characteristics, area of pasture and the productive orientation affected management. The impact of the former was very important. Region, along with the productive orientation, explained the largest proportion of the management variation.

All the management factors affected at least one of the performance variables, their importance being relative to the parameter being analysed. These management factors also explained a large proportion of the variation in the performance observed.

The information profiles were the only ones statistically related to the performance variables. This result showed again that those farmers with a preference for multiple information sources, especially from the technical advisors, obtained the highest level of milk yield and margins per cow per day.

Small variations in efficiency are found in Costa Rican dairy farms perhaps as consequence of the similar market conditions and quota effects of the sample used. No significant relationships between efficiency and biographical variables or the profiles were found.

A criticism of the econometric approach for evaluating the impact of farmer's managerial capacity on efficiency is that their effects should not be related to the farm performance directly but by their relation with management practices. As discussed before, the extent to which the managerial capacity affect the performance depends on the environmental and market conditions in which the manager and farm are located. From this point of view, the managerial capacity of the farmer should be taken into account by including management variables that are proved to be related to the managerial capacity of the farmer rather than including the farmer's characteristics directly into the econometric model as done in the studies of Moock (1981); Jamison and Moock (1984); Wang *et al* (1996); Adesina and Djato (1996); and Wilson and

Hadly (1998). Variables accounting for the management of the resources e.g. feeding strategy, and not only the gross feed purchases, would give better evidence of the impact of the manager on efficiency rather than including his/her educational level, for instance. An eventual direct relationship of the latter variable with efficiency would be, by nature, a reflection of some management practices not taken into account in the model that are confounded with education. If all the management practices, along with the gross inputs, were included, then no effects of the farmer's characteristics would be expected.

Chapter 8 General discussion of results and implications

8.1 Introduction

Having shown evidence of selected aspects of the decision-making process and their impact on the management and performance of the farms, it is now possible to discuss the results obtained with reference to the original hypothesis defined in chapter 2. Once this discussion is completed implications in terms of research, extension and development of decision-support systems are considered. Finally conclusions for future research are drawn.

8.2 Objectives of Costa Rican farmers

In chapter 2 the following null hypothesis was defined:

"*As normally assumed, the objectives of Costa Rican farmer are oriented to the maximisation of biological outcomes or profit of the farm, while other personal and familiar objectives are less important or not significant. These objectives are unaffected by farmers/farms characteristics*"

From the country point of view, this hypothesis can not be rejected since the monetary objectives were ranked amongst the most important goals for the farmers, while the familiar and personal goals were less important. However, when groups of farmers were defined, it was found that only around 50% of the farmers had an entrepreneurial orientation towards monetary outcomes of the farm. They ranked objectives like maximising incomes, revenue, and obtaining the best milk quality within the first 5 objectives. The other half had either a mixture of monetary, personal, and familiar objectives or a non-entrepreneurial orientation. From this point of view, this hypothesis should be rejected in its first part.

In respect of the effects of farmers/farm characteristics, although the results showed weak relationships between farmer's/farms' characteristics and the objective orientations, the hypothesis should also be rejected. Relatively small correlations between age, educational level and the size of the farm and some of the objectives were found. A small proportion of the variation was explained by these characteristics. This implies that other variables should be identified and taken into account in order to increase the predictability of objectives and to obtain a better understanding of how the objectives are defined and which are the factors affecting them.

The fact that 10 groups of farmers were necessary to explain the variation in the hierarchies of goals, is evidence that multiple objectives are found among the Costa Rican dairy farmers. This shows how heterogeneous a population can be even in relatively homogeneous conditions (at least from the market and production orientation points of view) in a small country. Maximising behaviour should no longer be assumed in decision-support systems nor in research and technology transfer activities. For the former, the results suggest that, in order to ensure a high adoption rate of these tools and their outputs, different groups of objective orientations should be taken into account and should be well represented into the objective functions. The challenge arising is how to represent these objective orientations in a tool that is evidently mathematical. For example, the objective orientation of the farmers in group GP2 (Table 4.11), the third biggest group in the country, is mostly in favour of milk quality, environmental issues, improving the standard of living of the family and saving money for the education of the children. The first question here is what does improving the standard of living mean? If the answer is obtaining goods and services that can be paid with money, then this objective is intrinsically a monetary objective that can be easily represented in the models. Nevertheless, if standard of living is defined by other less tangible things such as providing a good way of living, in the country side for instance, then the representation would be very difficult. Obviously, the meaning of "a good standard of living" is relative to the values of each farmer and therefore it is also necessary to take into account the real meaning of the objective from the farmer's point of view. For an objective like environmentally friendly farming, the picture is even more complicated to

represent. In this case the objective becomes a constraint, so the management alternatives should be constrained to avoid damage to the environment. This suggests that some of the objectives could be better treated as constraints.

The profiles defined in this research provide a wide variety of objective orientations that can be used to define better objective functions to represent multiple "types" of goals and constraints imposed by the farmers. These profiles should be represented in order to, first ensure the adoption of the decision-support systems as a tool, and secondly to ensure the adoption of solutions that come out from the models.

From the point of view of research and extension activities, the objective profiles defined in this research are useful in identifying the relevant level of research that is necessary for each type of farmer as well as the relevancy of the technologies to be offered to them. For example, creating and transferring of technologies than are designed to reduce costs and increase the efficiency and revenue of the firm and that involve high level of investments, risk and innovation, are more suitable for the farmer belonging to group GP4. Farmers belonging to this group are attached to investments, innovation and maximising incomes and revenue. In contrast, these technologies would be very unsuitable for farmers in the group GP2 (already explained above).

The relation between some of the economic objectives and the use of some technologies (chapter 7) demonstrates that some practices have been adopted as consequence of the objective orientations. For instance, maximisator-entrepreneur farmers (Ep4 and Ep6) used more technical advising and more reproductive and nutritional technologies than those non-entrepreneur pro-family farmers. Therefore, the knowledge of the farmer's objective can help in predicting the probability of a successful adoption of a new practice before expending the limited resources available for extension purposes.

With respect to the methodology used in this study, it is important to note that, although the participatory techniques were successful in recording the objective hierarchies, the number of objectives tested seemed to be relatively large (as in any exploratory exercise). The experience accumulated during the interviews and data analysis showed that a better approach to select the set of objectives to be tested, would

come from the farmers rather than from the opinion of the researchers and literature. Since some of the objectives tested had the same meaning to the farmers and because some of them were positively or negatively related, the number of objectives could be substantially reduced in future research. A better approach would be to record a large number of objective statements given by a group of farmers and then select a sub-set to be used in the sample.

One of the advantages of the Rokeach's technique (disadvantage from the point of view of the data analyst) is that a relatively large number of objectives can be evaluated in a relatively short period of time. This technique forces the respondent to rank the statements in a meaningful way. This makes the analysis more simple. However, the consistency of the ranking is not very easily tested (the data analyses and the relations found provide an internal validation of the consistency of the respondents in the work). In future research, a combination of this technique with other methods like paired comparisons (all objectives are compared against the others) and scoring technique (where several objectives can be equally scored) seems to be the best way to obtain a better understanding of the objectives hierarchies and test the consistency of the respondent. It is also necessary to document some qualitative information of reasons behind individual hierarchies.

Due to the complexity of the hierarchies when all the objectives were included together, the definition of separate profiles for the economic, personal and familiar points of view facilitated the analysis and interpretation of the results. When these three profiles are used together, they provided three different aspects of the orientation of the farmer (at the same time his/her overall orientation) that could subsequently be used to plan research and extension activities.

8.3 Who makes farming decisions?

The hypothesis to be tested in chapter 5 was:

"*Farming decisions are made by a single decision-maker, who takes into account the opinion of other members of the family and trusted people. This monopolisation is constant under different types of decisions and farmers'/farms' characteristics. Under this monopolisation no decision-making sub-units exist in the farm.*"

The empirical evidence leads to the rejection of this hypothesis. Although half of the farming decisions were made by the farmer alone, the other half were made by, or in conjunction with other people. These people included family members, farm staff and technical advisors. This evidence made it possible to define decision-making approaches that represented different levels of decentralisation of decision-making and define the proper decision-making unit acting within the farms. As in the case of objectives, the farmers'/farms' characteristics had significant effects on the definition of the profiles. However, the power of prediction was again very small showing the importance of more research to understand the factors affecting this process. Finally, it was demonstrated that the decentralisation of individual decisions is significantly affected by the intrinsic characteristics of the decision being taken. One of the most important findings was that some of the more frequently delegated decisions are quite strategic (the amount of concentrate per cow; which paddocks to graze, for instance) and that they involved considerable amounts of resources and have a big impact on the performance of the farm.

These findings have important implications for planning extension activities. The decision-making profiles can be used to define recommendation domains and the targets for the extension efforts. These activities should take into account all the actors involved in the decision-making process. Each actor, depending on his/her characteristics, should be treated differently, using different media and level of training. The fact that other people and, in some cases a lot of people, take part in the process, implies that

persuasion should no longer be directed only towards the farmer. For example, for the group of farmer labelled "Alone" (Figure 5.3), awareness, persuasion and training of the extension activities should be directed to the farmer his/her self. For, the group labelled "Family" the effort should be focused on the family as the decision-making unit. In the group "Alone and delegate" the extension should be directed to the farmer and delegated people separately and perhaps more strongly towards the latter (it is important to recall that those farmers who delegated more decision are less dedicated to farming). A similar approach should be addressed to farmers belonging to the group "Alone and Shared".

For research into adoption processes, the high level of involvement of other people in the decision-making process implies that adoption rates and lags should be also explained as a function of the characteristics of the decision-making unit and all actors involved. For example, the negative relationship between the level of use of technical advice and some reproductive and nutritional technologies with the decision-making approach in favour of delegation, provides evidence of the necessity of studying these relationships in more detail. Rejection at the implementation phase should be studied since, the delegated people are those who, at the end of the day, represent the ultimate technology adopter or rejecter. It is necessary to take into account these decision-making sub-units in extension activities.

The relationship between intrinsic characteristics of decisions (e.g. reversibility, term, investment level etc) and the level of involvement of different decision-making units supplies important information to predict who will decide if a new practice is adopted or rejected. Thereby the proper target for awareness, persuasion and training can be predicted before a new technology is made available.

In a broader scale, the discussion here, along with the evidence showed in chapter 2, represents a challenge to the eco-regional scale system analyses, where some decision-support systems, designed for policy decision-makers, are supposed to give the alternative solutions for a more aggregated system management. The question is "are we able the make decisions for a regional level if we don't even know who makes the decisions at the unit level of the regional system? The results showed here indicate that

aggregated planning is also a matter of identifying the actor(s) to whom persuasion should be addressed to make the whole system to behave as the policy makers want.

8.4 Personal Informational sources

"*Personal information sources used by farmers to make decisions are the same regardless the step of the decision-making in which he/she is. The majority of information for farming decision comes from the formal sector through the extension services and technical advisors and that it is independent of the farmers'/farms' characteristics* "

The evidence showed that the family and technical advisors were the most important personal information sources regardless to the step of the decision-making process. However, their relative importance changes considerably though the steps. The role of the family was found to be more important in "problem detection" and "seeking for opinion" while the role of the technical advisors was shown to be more important in "seeking for problem solutions" and "seeking for new practices". The role of other people such as farm staff was shown to be strategic in " problem detection", while the role of other farmers and commercial agents was very limited. This result should be considered as a behaviour of the population itself and not the behaviour of individual farmers. When the scores of individual farmers were analysed, it was clear that when an information source was preferred, this source tended to be preferred in all of the analysed steps of the decision-making process. This result provides evidence to support of the first part of the null hypothesis.

With respect to the second part, the informational profiles defined in chapter 6 (see Figure 6.7 and Table 6.4) provide evidence that both, informal information, from the family and farm staff, and "formal" information coming from technical advisors is used in decision-making. There are some groups of farmers who prefer sources like other farmers and commercial agents. This result shows the diversity of preferences and therefore leads to the rejection of the second part of the hypothesis.

Finally, the farmers'/farms' characteristics were shown to affect the level of involvement of different sources of information in the process. Aspects like age, level of dedication to farming, educational level, distance of population centres and the size of the farm, had significant effects. Moreover, it was in this aspect of decision-making, where these characteristics had the largest effect and the highest prediction power. However it was still very low. As in the case of objectives and decision-making approaches, this result indicates that more research to identify more variables driving the preference towards different sources of personal information is required. From this evidence it is concluded that the last part of the hypothesis should be rejected.

The clustering process demonstrated the high level of variability of combinations with respect to preferences towards different trusted people. This variability made it necessary to define 9 groups of farmers in order to account for a considerable proportion of the variance.

The implication of these findings are also more related to extension activities. The profiles defined here can be used as a proxy of the informational flows of the farmers. This is key information to define strategies to make new practices and technologies available to the farmer. These profiles also give information on the level of openness of the farmers and key information to select the best strategy and persuasion to ensure higher adoption levels and reduce the adoption lag. For example, farmers belonging to groups 7 and 8 (Figure 6.7) are more likely to be aware of new practices available in the media, since they are very open to different information sources. It means that less effort should be expended in them and more effort should be addressed to farmer belonging to group 1 and 9, who are very limited in informational sources. The target of the extension activities should be directed to the family in those farmers belonging to group 2, since only they are open to this information source.

It is important to stress that information refers not only to "awareness of new practices" or technologies but also to activities such as "detection of problems in the farm". Since, for example, the farm staff plays an important role in this activity, special efforts should be made in terms of training them how to look for problems. The introduction of herd health protocols, for instance, which is a very novel way of

preventing health problem in dairy herds, should be directed not only to the farmer but (perhaps even more importantly) to the farm staff. With respect to the important role of the family members as opinion sources (see Figure 6.6), there is evidence of necessity to focus effort on technical training on members of the family in respect of new practice or technology. In this way, opinion from these people will be more informed and probably favour the new practice. A similar approach should be given to the technical advisors. Their influence seems to be very important in "problem solution" and "awareness of new practices" they become good allies for the extension and research sector to promote, persuade and train farmers and their trusted people to ensure higher level of adoption and reduction of the adoption lag. Where private technical advisors exist, and they are the most important, and sometimes the only source of technical knowledge, these actors should be considered within the domain of the extension activities and training.

The methodology used here, although derived from other disciplines such as marketing, proved to be suitable for studying preferences. It is not surprising since extension activities are also a marketing business with the only difference that the products are technologies and the consumers are farmers.

8.5 The human component of the system and its interaction with management practices and performance

"*The management practices of the farm are not related to objective orientation, the decision-making approach or the personal informational source used by the decision-making unit*"

" *The performance of the farm is not related (directly or indirectly) to objective orientation, the decision-making approach or the personal informational source used by the decision-making unit*"

In chapter 7, all the farmer's profiles developed throughout the thesis were integrated together in order to challenge these hypotheses. This integrated approach lead to the development of a more comprehensive proxy of the human component of the system. In

contrast to the majority of studies reviewed in chapter 2, this study took into account not only the biographical variables of the farmers, but, through the profiles, several aspects of his/her managerial characteristics and therefore capacity. From the evidence that came out, these two hypotheses should be rejected. It was demonstrated that there were some relationships between the farmer's variables, the management and some direct impacts on the performance of the farm. The decision-making approach towards "sharing decisions", the objective orientation towards "maximisation of incomes" and the level of "openness towards several information sources" were shown to have the biggest positive impact on management practices and performance. However not effects on efficiency were found.

This evidence has important implications in terms of research and extension. Firstly this provides more evidence showing how the human component of the system strongly affects its management and performance, and not only the environment, resource availability and inputs. Secondly, it provides more evidence of the impact of the human component on the adoption process. For instance, technical advising and some reproductive and nutritional strategies have been adopted by farmers more opened to several information sources, farmers with maximising orientation, with a sharing decision-making approach and with higher educational level (Table 7.4). Again the farmers with some advantages in managerial capacity have been the ones who "enjoy" the knowledge and the positive impacts of technology. On the contrary those farmers with the opposite traits, have not been so lucky. Now, is it a matter of farmers with some personal deficiencies that lead to the rejection of the practices? or, is it the outcome of some deficiencies of the extension agencies in designing the proper strategies for different type of farmers? (as stated by Wadsworth, 1995). The latter seems to be more likely. The third implication is that once the impact of some practices has been quantified, these results can (and should) be used to feed back the adopters of the technology in order to justify their use in the future (this is more important in high investment practices). This information can also be used for persuasion purposes showing the impact of some recommended practices on the performance to the no (yet) adopters. Although more difficult, showing farmers that some managerial characteristics

(openness, for instance) are positively related to performance could lead to a self-evaluation by the farmers and perhaps a change in attitudes towards the decision-making approach, objectives and informational sources.

The study intended to provide evidence of the human component of the farmer in a sequential way. Impact was evaluated at the management level, then the impact of the management on the performance of the farm. Although some direct relationships between farmer and performance were done, the cause-effect logic says that the extent to which the human component has effect on the performance is through management. This point of view led to a criticism of the traditional approach of evaluation the managerial capacity on performance, mostly in econometric models. It is argued that if all the management variables (not only the inputs, capital etc.) are included into the models, then no effects of the farmer's characteristics would be expected. From this point of view, the econometric models should include variables representing the management of the resources rather that the education of the farmer, for instance. The evaluation of the impact of the human component should be made using the management variables as dependent variables.

8.6 Final considerations

The conceptual model of the decision-making process developed in chapter 2 shows the complexity of the process and the necessity of studying it using a systematic approach. This leads to the study of different components of the process without losing sight of the whole picture of the system. The literature reviews demonstrated that some of the components and processes are relatively well known and documented. However even in these cases, the empirical evidence is very specific to the conditions under study. In some of the components and processes there is very limited knowledge and less empirical evidence. The empirical findings here contribute towards gaining more knowledge and a better understanding of the process. They provide evidence from a developing country, where scarce evidence is available. This helps to identify those aspects that can be regarded as more universal and less country or regional related.

Finally, this thesis provides information that can be directly used to make research and extension more effective.

In conclusion, is could be said that the major contribution of this work is providing a more comprehensive representation of the human component of the dairy farm systems in Costa Rica.

8.7 Future research

It is important to stress that the whole conceptual model developed in chapter 2, is a major hypothesis to be tested. A series of case studies in Costa Rica and Bolivia have been done in order to provided more knowledge of the whole process. This forthcoming knowledge will, in conjunction with more empirical evidence, contribute to a better understanding of the decision-making process. It is, in conclusion, necessary to continue studying the human component of agricultural systems until a comprehensive system of decision-making knowledge is gained.

References

Achten, J.M.F.H., Nienhuis, J.K., and Alleblas, J.T.W. 1983. A quantitative model for measuring management level. Acta Horticulturae. 135:39-61.

Adesina, A.A. and Djato, K.K. 1996. Farm size, relative efficiency and agrarian policy in Cote d'Ivoire: Profit function analysis of rice farms. Agricultural Economics. 14:93-102.

Andison, N.B. 1989. Getting beyond the management illusion. Canadian Journal of Agricultural Economics. 37:743-746.

Austin, E.J., Deary, I., Gibson, G., McGregor, M.J., and Dent, J.B. 1996. Attitudes and values of Scottish Farmers: "Yeoman" and 'Entrepreneur" as factors, not distinct types. Rural Sociology. 61:464-474.

Battese, G.E. 1992. Frontier production functions and technical efficiency: a survey of empirical applications in agricultural economics. Agricultural Economics. 7:185-208.

Beaudeau, C., Fourichon, C., Frankena, K., and Seegers, C. 1993. Associations between health disorders and culling of dairy cows. A review. Livestock Production Science. 35:213-236.

Berlan, M. 1988. The division of labor and decision-making in farming couples: Power and negotiation. Sociologia Ruralis. 28:271-292.

Blum, A. 1989. Use of different information sources for decision making by traditional farmers in a progressive knowledge system. Journal of Extension Systems. 5:60-73.

Bokemeier, J. and Garkovich, L. 1987. Assessing the influence of farm women self-identity on task allocation and decision-making. Rural Sociology. 52:13-36.

Bryden, J. 1994. Interactions between farm households and the rural community: effects of non-agricultural elements in farm household decision making on farming systems. *In* Rural and Farming Systems Analysis. J.B. Dent and M.J. McGregor, ed. CAB International, Wallingford.

Camara Nacional de Productores de Leche. 1998. Cifras importantes. Pages 120-135. *In* Proceeding 1er Conferencia Regional de la Federacion Centroamericana y del Caribe del Sector Lacteo. 98. San Jose.

Carroll, J.D. 1972. Individual differences and multidimensional scaling. p. 123-145. *In* Theory and applications in behavioral science. R.N. Shepard, A.K. Rommeny and S.B. Nerlove, ed. Seminar Press, New York.

Chambers, R. 1983.Putting the last first. Longman; London:

Chambers, R., Pacey, A. and Thrupp, L.A. 1989.Farmer first: Farmer innovations and agricultural research. Intermediate Technology Publications; London:

Costa, F.P. and Rehman, T. 1999. Exploring the link between farmers' objectives and the phenomenon of pasture degradation in beef production systems of Central Brazil. Agricultural Systems. 61:135-146.

Dent, J.B. 1992. Potential for systems simulation in farming systems research. p. 325-339. *In* Systems Approaches for Agricultural Development. F. Penning de Vries, P. Teng, and K. Matselaar, ed. Kluwer Academic Publisher. 02/12/91. Dordrecht.

Dent, J.B. 1994. Theory and practice in FSR/E: Consideration of the role of modelling. p. 100-110. *In* Systems-Oriented Research in Agriculture and Rural Development. C. Rawski, ed. CIRAD-SAR. 21/11/94. Montpellier.

Dent, J.B. 1995. Towards a general paradigm for decision making. Ciencias Veterinarias. 1-2:67-70.

Dent, J.B., McGregor, M.J., and Edwards-Jones, G. 1994. Integrating livestock and socio-economic systems into complex models. p. 25-36. *In* The Study of Livestock Farming Systems in a Research and Development Framework. A. Gibon and J.C. Flamant, ed. Wageningen Press. 11/12/92. Wageningen.

Errington, A. 1986. The delegation of decision on the farm. Agricultural Systems. 19:299-317.

Errington, A. and Gasson, R. 1994. Farming system and family business. p. 181-192. *In* Rural and Farming Systems Analysis. European Perspectives. J.B. Dent and M.J. McGregor, ed. CABI, Wallingford.

Fairweather, J.R. and Keating, N.C. 1994. Goals and management styles of New-Zealand farmers. Agricultural Systems. 44:181-200.

FAOSTAT. 1999. On line agricultural database collection. FAOSTAT statistics database. Food and Agriculture Organisation of the United Nations. website www.apps.fao.org.

Farrel, M.J. 1957. The measurement of productive efficiency. Journal of the Royal Statistical Society. 120:253-290.

Ferreira, G. 1997. Understarstanding decision making at farm level. PhD. Thesis. University of Edinburgh. 469p.

Foddy, W. 1993.Constructing questions for interviews and questionaries. Theory and practice in social research. Cambridge University Press; Cambridge: 227p.

Ford, S.A. and Babb, E.Y. 1989. Farmers sources and use of information. Agribusiness. 5:465-476.

Frank, B.R. 1995. Constraints limiting innovation adoption in the north Queensland beef industry. II: Non-adoption is an intelligent response to environmental circumstances. Agricultural Systems. 47:323-346.

Frank, B.R. 1997. Adoption of innovations in the North Queensland beef industry. III: Implication for extension management. Agricultural Systems 55:347-358.

Gasson, R. 1971. Use of sociology in agricultural economics. Journal of Agricultural Economics. 22:29-38.

Gasson, R. 1973. Goals and values of farmers. Journal of Agricultural Economics. 24:521-538.

Goodger, W.J., Galland, J.C., and Christiansen, V.E. 1988. Survey of milking management practices on large dairies and their relationship to udder health and production variables. Journal Dairy Science. 71:2525-2542.

Harrison, S.R., Thornton, P.K., and Dent, J.B. 1990. The IBSNAT project and agricultural experimentacion in developing countries. Experimental Agriculture. 26:369-380.

Henderson, T.H. and Gomes, P.I. 1982. Family-structure, attitudes and decision-making among caribbean peasant farmers. Agricultural Administration. 9:257-265.

Herrero, M. 1997. Modelling dairy grazing systems: An integrated approach. PhD. Thesis. University of Edinburgh. 282p.

Herrero, M., Fawcett, R.H., and Dent, J.B. 1999. Bio-economic evaluation of dairy farm management scenarios using integrated simulation and multiple-criteria models. Agricultural Systems. 62:169-188.

Infoagro/SEPSA/BCCR. 2000. website www.infoagro.go.cr.

Jacobsen, B.H. 1994. Farmer's decision making behaviour: Empirical finding from Denmark. Pages 77-89. *In* Farmers' Decision Making: A descriptive approach. B.H. Jacobsen, D.E. Pedersen, J. Christensen, and S. Rasmussen, ed. Institute of Agriculture Economics and The Royal Veterinary and Agricultural University Denmark. 03/05/94. Copenhagen.

Jamison, D.T. and Moock, P.R. 1984. Farmer education and farm efficiency in Nepal: The role of schooling, extension services, and cognitive skills. World Development. 12:67-86.

Jones, G.E. 1967. The adoption and diffusion of agricultural practices. World Agricultural and Rural Sociology Abstract. 9:1-33.

Kiernan, N.E. and Heinrichs, A.J. 1994. Identification of farm manager types through cluster analysis of calf and heifer management practices. Preventive Veterinary Medicine. 18:225-236.

Manly, B.F.J. 1994. Multivariate statistical methods. 2nd ed. Chapman & Hall; London: 215p.

McClymont, D. 1984. Decision-making process of commercial farmers in Zimbabwe. Agricultural Administration. 17:149-162.

McGregor, M.J., Willock, J., Dent, J.B., Deary, I., Sutherland, A., Gibson, G., Morgan, O., and Grieve, R. 1995. Links between psychological factors and farmer decision making. Farm Management. 9:228-238.

Moock, P.R. 1981. Education and technical efficiency in small-farm production. Econ Dev Cultural Change. 29:723-739.

Mueller, R.A.E. and Jansen, H.G.P. 1988. Farmer and farm concepts in measuring adoption lags. Journal of Agricultural Economics, UK. 39:121-124.

Öhlmér, B. 1992. Effects of information technology on the data need in farm management. Swedish Journal of Agricultural Research. 22:181-188.

Öhlmér, B., Brehmer, B., and Olson, K. 1994. Decision making process of Swedish farmer: Detection of problems. Pages 247-260. *In* Farmers' Decision Making: A descriptive approach. B.H. Jacobsen, D.E. Pedersen, J. Christensen, and S. Rasmussen, ed. Institute of Agriculture Economics and The Royal Veterinary and Agricultural University Denmark. 03/05/94. Copenhagen.

Öhlmér, B., Olson, K., and Brehmer, B. 1998. Understanding farmers' decision making processes and improving managerial assistance. Agricultural Economics. 18:273-290.

Perkin, P. and Rehman, T. 1994. Farmers' objectives and their Interactions with business and life styles: Evidence from Berkshire, England. p. 193-212. *In* Rural and Farming Systems Analysis. J.B. Dent and M.J. McGregor, ed. CAB International, Wallingford.

Pomareda, C. 1994. Interdependencia de la produccion lechera y la industria de productos lacteos: desafios para la transformacion productiva. Seminario taller: Situacion actual y perspectivas de la actividad lechera costarricense ante el proceso de apertura comercial. Camara Nacional de Productores de Leche.

Rogers , E. M. (1983). Diffusion of innovations. Third ed. The Free Press; New York.

Rhoades, R. 1989. The role of farmers in the creation of agricultural technology. p. 3-8. *In* Farmer first: Farmer innovation and agricultural research. R. Chambers, A. Pacey and L.A. Thrupp, ed. Intermediate Technology Publications, London.

Röling, N. 1994. The interface between farmers' and research worker' knowledge. Pages 315-322. *In* Systems-Oriented Research in Agriculture and Rural Development. C. Rawski, ed. CIRAD-SAR. 21/11/94. Montpellier.

Röling, N. and Engel, P.G.H. 1991. The development of the concept of agricultural knowledge and information systems (AKIS): implications for extension. p. 125-138. *In* Agricultural Extension: Worldwide Institutional Evolution and Forces for Change. W.M. Rivera and D.J. Gustafson, ed. Elsevier, Amsterdam.

Rosenberg, H.R. and Cowen, P. 1990. Management difference and dairy results. Agribusiness. 6:267-279.

Rougoor, C.W., Trip, G., Huirne, R.B.M., and Renkema, J.A. 1998. How to define and study farmers' management capacity: Theory and use in agricultural economics. Agricultural Economics. 18:261-272.

SAS. 1994. SAS/STAT User's guide. SAS Institute,

Savary, S. 1993. Rice farmers' background, perceptions of pests, and pest-management actions: a case-study in the philippines. Netherlands Journal of Plant Pathology. 99:181-190.

Sipilainen, T. 1994. Empirical finding on farmers' decision-making in long-term investment. p. 91-102. *In* Farmers' Decision Making: A descriptive approach. B.H. Jacobsen, D.E. Pedersen, J. Christensen, and S. Rasmussen,

ed. Institute of Agriculture Economics and The Royal Veterinary and Agricultural University Denmark. 03/05/94. Copenhagen.

Sisodia, J. 1985.Role of farm women in agriculture: a study of Chambal command area of Madhya Pradesh. Indian Journal of Agricultural Economics 40:223-230.

Solano, C.E., Bernues, A., Rojas, F., Joaquin, N., Fernandez, W., Herrero, M. 2000. Relation between management intensity and structural and social variables in dairy and dual-purpose systems in Santa Cruz, Bolivia. Agricultural Systems [In Press]

Stefanou, S.E. and Saxena, S. 1988. Education, experience, and allocative efficiency : A dual approach. American Agricultural Economics Association. 70:338-345.

Sutherland, A.J.,McGregor, M.J.,Dent, J.B.,Willock, J.,Deary, I.,Gibson, G.,Grieve, R., and Morgan, O. 1996. Edinburgh farmer decision making study: elements important to the farmer. p. 162-171. *In* Farmers in small-scale and large larde-scale farming in a new perspective.Objectives, decision making and information requirements. G. Beers, R.B.M. Huirne and H.C. Pruis, ed. Agricultural Economic Research Institute (LEI-DLO),

Timko, M. and Loyns, R.M.A. 1989. Market information needs for Prairie farmers. Canadian Journal of Agricultural Economics. 37:609-627.

Vail, D.J. 1982. Women and small farm revival: The division of labor and decision-making on Maines organic farms. Review of Radical Political Economics. 13:19-32.

Voh, J.P. 1982. A study of factors associated with the adoption of recommended farms practices in Nigeria village. Agriculture Administration. 9:17-27.

Wadsworth, J. 1990. Developing efficient extension strategies: Results of an experiment involving Costa Rican livestock producers. Agricultural Systems. 34:259-275.

Wadsworth, J. 1995. Adoption of innovations by Costa Rican livestock producers under different levels of extension intensinty: Predicted versus observed behaviour. Agricultural Systems. 49:69-100.

Wang, J., Cramer, G.L., and Wailes, E.J. 1996. Production efficiency of Chinese agriculture: evidence from rural household survey data. American Journal of Agricultural Economics. 15:17-28.

Wilson, P. and Hadley, D. 1998. Measuring and exploring technical efficiency in UK potato production. Journal of Agricultural Economics. 39:294-303.

World Bank. The state in a changing world. World development report. 1997; 1997. p.215

Appendix 1. Code book of the conceptual model of the decision-making process

Decision making unit (DMU)	DMUFM	Family members				
	DMUIF	Information flow within decision making unit	DMUIF1	Inf. negotiation to objectives		
			DMUIF2	Inf. socio-eco. paramet. to probl.detection		
			DMUIF3	Inf. objectives to evaluation		
			DMUIF4	Inf. problem detection to objectives		
			DMUIF5	Inf. rejected to definition of solutions		
			DMUIF6	Inf. family menbers to monitoring		
	DMUMP	Monitoring of socio-economic situation in family	DMUMPA	Education		
			DMUMPB	Health status		
			DMUMPC	Goods availability		
			DMUMPD	Security		
	DMUNEG	Negatiation process within the family				
	DMUOBJ	Production goals	DMUOBJA	Technical goals		
			DMUOBJB	Financial goals		
	DMUP	Decision-making process	DMUPAD	Adjustments to routine		
			DMUPEV	Evaluation of solution	DMUPEVA	Mental forecast
					DMUPEVB	Instrum. forecast
					DMUPEVC	Trials
			DMUPPD	Problem detection or anticipation		
			DMUPPDE	Problem definition		
			DMUPSO	Definition of problem solutions.		
	DMUPRT	Pool of rejected tecnologies				
	DMUSEP	Socio-economic parameters	DMUSEPA	Financial situation		
			DMUSEPB	Educational achivements		
			DMUSEPC	Illnesses prevalence		
			DMUSEPD	Goods availability		
			DMUSEPE	Resources availability		
	DMUT	Only Decision taker				

Appendix 1. continuation

Farm environment (FARM)	FARMDEL	Delegation of actions and decisions		
	FARMDS	Decision-making sub-units	FARMDSAS	Assessment of technical parameters
			FARMDSDM	sub unit decision-making
			FARMDSDS	Definition of solution
			FARMDSMO	Modification of farmer's decision
			FARMDSOB	Sub' units objectives
			FARMDSPD	Problem definition
			FARMDSRE	Re-evaluation of farmer s decisions
	FARMIF	Information flows	FARMIF1	Inf. instruments to technical parameter
			FARMIF2	Inf. monitoring to instruments
			FARMIF3	Inf. subsystems to monitoring
			FARMIF4	Inf. technical parameter to decision sub-units
			FARMIF5	Inf. operator objectives to re-evaluation
	FARMIM	Monitoring of farm subsystems	FARMIMA	Milk production
			FARMIMB	Growth
			FARMIMC	Health
			FARMIMD	Pasture condition
	FARMIMP	Implementation of decision and adjustments		
	FARMMI	Monitoring tools	FARMMIA	Management information systems
			FARMMIB	Manual records
			FARMMIC	Mental perception
	FARMSS	Farm sub-systems		
	FARMTP	Technical parameters	FARMTPA	Biological performance
			FARMTPB	Financial performance

Appendix 1. continuation

Socio economic environment (SECE)	SECEIF	Information flow within socio-economic environment	SECEIF1	Inf. pool of inf. to socio-economic parameters
			SECEIF2	Inf. monitoring to information digesters
			SECEIF3	Inf. information digesters to pool of inform.
			SECEIF4	Inf. monitoring to pool of information
			SECEIF5	Inf. trusted people to monitoring
			SECEIF6	Inf. information media to monitoring
	SECEIFM	Information media		
	SECEIM	Monitoring of information from socio-economic environment	SECEIMA	Social standards and values
			SECEIMB	Rural People Knowledge
			SECEIMC	Other s farmers experience
			SECEIMD	Research and extension knowledge
			SECEIME	Commercial knowledge
			SECEIMF	National and regional economic situation
			SECEIMG	Trusted people opinion
	SECEPI	Information pool	SECEPIA	Common practices
			SECEPIB	New technologies
			SECEPIC	Opinion
	SECERP	Socio-economic and technical reference parameters	SECERPA	Acceptable standards of living
			SECERPB	Acceptable technical parameters
			SECERPC	Acceptable practices
	SECETP	Trusted people-key informants	SECETPA	Trusted people: Family members
			SECETPB	Trusted people: Friends
			SECETPC	Trusted people: Technicians
			SECETPD	Trusted people: Sellers
			SECETPE	Trusted people: Operators
	SECIDI	Information digesters		

Appendix 1. continuation

Inter-systems	ISAC	Inter system actions	ISAC1	Action. family members as trusted people
			ISAC2	Action. family members in the negotiation
			ISAC3	Action. farmers as trusted people or viceversa
	ISIF	Inter system Information flows	ISIF1	Inf. reference parameter to negotiation
			ISIF2	Inf. reference parameter to objective
			ISIF3	Inf. reference parameter to dm sub-unit object
			ISIF4	Inf. instruments to problem definition
			ISIF5	Inf. technical parameter to problem detection
			ISIF6	Inf. pool of information to problem definition
			ISIF7	Inf. pool of information to definition of solu.
			ISIF8	Inf. pool of information to evaluation of solu.
			ISIF9	Inf. pool of information to definition of sol2

Appendix 2. Least Squares Means and confidence intervals (90%) for the economic objectives by cluster

Cl	Inve			Monr			Maxi			Maxr			Educ			Expa			Inc			Proq		
1	11.6	**13.4**	15.1	2.7	**4.6**	6.6	4.2	**5.9**	7.6	3.5	**5.2**	6.9	8.5	**10.8**	13.1	5.0	**6.8**	8.6	3.7	**5.4**	7.0	8.6	**9.8**	11.1
2	4.0	**5.3**	6.5	12.0	**13.5**	14.9	7.0	**8.3**	9.5	6.7	**8.0**	9.3	8.9	**10.6**	12.2	3.6	**4.9**	6.2	4.1	**5.3**	6.5	1.3	**2.3**	3.2
3	6.0	**7.9**	9.8	6.0	**8.1**	10.3	10.4	**12.3**	14.2	7.1	**9.0**	10.9	3.7	**6.2**	8.7	1.4	**3.3**	5.3	3.5	**5.3**	7.2	4.1	**5.4**	6.8
4	8.1	**9.2**	10.4	9.4	**10.7**	12.0	3.0	**4.1**	5.2	3.0	**4.1**	5.2	7.4	**8.8**	10.3	9.7	**10.8**	12.0	5.6	**6.7**	7.7	2.4	**3.2**	4.0
5	8.9	**10.4**	11.9	6.3	**7.9**	9.6	5.9	**7.3**	8.8	8.3	**9.7**	11.2	4.0	**5.9**	7.9	8.6	**10.1**	11.7	9.4	**10.8**	12.2	1.4	**2.5**	3.5
6	3.6	**5.6**	7.5	10.2	**12.3**	14.5	1.0	**2.9**	4.8	1.5	**3.4**	5.4	10.4	**12.9**	15.4	1.5	**3.4**	5.4	1.5	**3.3**	5.2	5.4	**6.8**	8.2

Appendix 2 cont.: Least Squares Means and confidence intervals (90%) for the personal objectives by cluster

Cl	Redr			Envi			Redw			Reco			Timo			Innov		
1	11.7	**12.7**	13.8	8.5	**9.8**	11.1	11.3	**12.4**	13.6	12.7	**13.9**	15.2	12.2	**13.4**	14.5	7.5	**8.8**	10.2
2	3.3	**4.4**	5.5	3.4	**4.8**	6.2	10.5	**11.7**	12.9	15.4	**16.7**	18.0	9.5	**10.8**	12.0	7.6	**9.1**	10.5
3	8.1	**9.3**	10.6	2.8	**4.3**	5.9	13.7	**15.1**	16.5	10.3	**11.8**	13.2	7.6	**9.0**	10.4	11.6	**13.3**	14.9
4	5.9	**7.1**	8.3	8.6	**10.1**	11.6	7.3	**8.7**	10.1	15.3	**16.8**	18.2	12.6	**14.0**	15.4	3.4	**5.0**	6.6
5	7.2	**8.6**	10.0	3.1	**4.8**	6.5	13.7	**15.3**	16.9	9.0	**10.6**	12.2	13.0	**14.6**	16.2	4.6	**6.4**	8.2
6	11.9	**13.2**	14.4	11.7	**13.2**	14.7	6.9	**8.2**	9.6	12.9	**14.4**	15.8	8.1	**9.5**	10.8	9.9	**11.5**	13.0
7	6.4	**8.0**	9.6	3.9	**5.9**	7.8	4.3	**6.0**	7.7	13.4	**15.3**	17.1	5.0	**6.8**	8.5	10.7	**12.8**	14.8

Appendix 2 cont. :Least Squares Means and confidence intervals (90%) for the familiar objectives by cluster

Cl	Lsma			Inhe			Lsin		
1	12.4	**13.4**	14.3	13.3	**14.3**	15.4	3.0	**3.9**	4.9
2	12.7	**13.7**	14.8	14.0	**15.1**	16.3	10.4	**11.4**	12.4
3	4.7	**5.8**	6.9	11.8	**13.1**	14.3	6.3	**7.4**	8.5
4	14.7	**15.8**	17.0	6.7	**8.0**	9.3	3.4	**4.5**	5.6
5	6.3	**7.5**	8.6	11.7	**12.9**	14.2	14.0	**15.1**	16.2
6	12.0	**13.3**	14.7	3.6	**5.1**	6.6	11.2	**12.6**	13.9
7	4.8	**6.1**	7.4	3.5	**5.0**	6.5	2.3	**3.7**	5.0

Appendix 3. Least square means and confidence limits (90%) for all objectives by cluster

Cl	Inve			Monr			Maxi			Maxr			Educ			Expa			Inc			Proq			Redr		
1	11.7	**13.7**	15.6	3.8	**6.2**	8.7	2.2	**4.2**	6.2	0.8	**2.9**	5.0	6.4	**9.0**	11.6	6.1	**8.3**	10.6	5.0	**7.0**	9.0	4.6	**6.4**	8.2	10.3	**12.1**	14.0
2	7.2	**8.8**	10.4	8.0	**9.9**	11.9	7.0	**8.6**	10.2	7.5	**9.2**	10.9	4.5	**6.6**	8.7	5.5	**7.4**	9.2	6.9	**8.5**	10.1	2.5	**3.9**	5.4	4.4	**5.9**	7.3
3	4.6	**6.1**	7.6	9.0	**10.9**	12.8	3.5	**5.0**	6.5	4.2	**5.8**	7.4	9.8	**11.8**	13.8	2.6	**4.4**	6.2	2.2	**3.8**	5.4	4.5	**5.9**	7.3	7.0	**8.5**	9.9
4	1.8	**4.2**	6.6	8.5	**11.5**	14.5	9.7	**12.2**	14.6	3.9	**6.5**	9.1	7.9	**11.2**	14.4	1.4	**4.2**	6.9	4.7	**7.2**	9.7	-1.2	**1.0**	3.2	8.7	**11.0**	13.3
5	6.3	**8.7**	11.1	6.8	**9.8**	12.8	0.7	**3.2**	5.6	1.4	**4.0**	6.6	7.4	**10.7**	13.9	8.1	**10.8**	13.6	1.2	**3.7**	6.2	1.0	**3.2**	5.4	6.6	**8.8**	11.1
6	5.8	**7.2**	8.6	10.0	**11.8**	13.5	3.7	**5.1**	6.5	4.0	**5.4**	6.9	7.9	**9.7**	11.6	7.7	**9.3**	10.9	5.2	**6.7**	8.1	1.1	**2.4**	3.7	6.2	**7.5**	8.8
7	7.8	**10.0**	12.2	3.4	**6.1**	8.9	5.9	**8.1**	10.4	4.9	**7.3**	9.7	4.4	**7.4**	10.4	4.1	**6.7**	9.3	4.1	**6.4**	8.7	3.8	**5.9**	7.9	11.7	**13.9**	16.0
8	9.6	**12.5**	15.4	3.1	**6.8**	10.4	3.8	**6.8**	9.7	4.1	**7.3**	10.4	1.6	**5.5**	9.4	3.9	**7.3**	10.6	3.2	**6.3**	9.3	1.3	**4.0**	6.7	5.0	**7.8**	10.5
9	3.8	**6.8**	9.7	10.3	**14.0**	17.7	8.8	**11.8**	14.7	6.3	**9.5**	12.7	6.3	**10.3**	14.2	-0.9	**2.5**	5.9	3.2	**6.3**	9.3	2.8	**5.5**	8.2	7.0	**9.8**	12.5
10	9.1	**11.3**	13.5	8.1	**10.9**	13.6	2.7	**5.0**	7.3	6.2	**8.6**	11.0	4.2	**7.1**	10.1	9.0	**11.6**	14.1	6.1	**8.4**	10.7	2.8	**4.9**	6.9	10.2	**12.3**	14.4

Appendix 3 cont.

Cl	Envi			Redw			Reco			Timo			Innov			Lsma			Inhe			Lsin		
1	6.1	**8.1**	10.1	7.7	**10.0**	12.3	12.9	**14.6**	16.2	7.4	**9.2**	11.0	8.8	**10.9**	12.9	12.6	**14.7**	16.8	7.9	**9.8**	11.7	2.1	**4.1**	6.1
2	3.3	**4.9**	6.4	9.9	**11.7**	13.6	15.0	**16.4**	17.7	11.2	**12.6**	14.1	5.3	**7.0**	8.7	12.6	**14.3**	16.0	10.6	**12.1**	13.7	3.6	**5.2**	6.8
3	9.8	**11.3**	12.9	8.2	**10.0**	11.8	14.6	**15.9**	17.2	9.5	**10.9**	12.3	7.2	**8.8**	10.4	10.2	**11.8**	13.4	10.1	**11.6**	13.1	8.5	**10.1**	11.6
4	5.9	**8.3**	10.8	8.3	**11.2**	14.0	7.8	**9.8**	11.9	13.1	**15.3**	17.6	4.0	**6.5**	9.0	4.8	**7.3**	9.9	10.8	**13.2**	15.5	9.7	**12.2**	14.6
5	7.6	**10.0**	12.4	8.5	**11.3**	14.2	14.4	**16.5**	18.6	10.6	**12.8**	15.1	2.8	**5.3**	7.9	10.1	**12.7**	15.2	13.2	**15.5**	17.8	3.6	**6.0**	8.4
6	3.4	**4.8**	6.2	10.2	**11.8**	13.5	12.6	**13.8**	15.0	10.0	**11.3**	12.6	9.5	**10.9**	12.4	8.5	**9.9**	11.4	13.6	**14.9**	16.3	9.0	**10.4**	11.8
7	11.0	**13.3**	15.5	9.5	**12.1**	14.8	12.7	**14.6**	16.5	12.9	**15.0**	17.1	7.4	**9.7**	12.1	5.6	**8.0**	10.4	4.7	**6.9**	9.0	-0.7	**1.6**	3.8
8	3.3	**6.3**	9.2	7.0	**10.5**	14.0	12.0	**14.5**	17.0	4.3	**7.0**	9.7	11.7	**14.8**	17.8	9.4	**12.5**	15.6	6.2	**9.0**	11.8	11.5	**14.5**	17.5
9	7.5	**10.5**	13.5	5.0	**8.5**	12.0	13.7	**16.3**	18.8	5.5	**8.3**	11.0	3.7	**6.8**	9.8	8.1	**11.3**	14.4	-0.6	**2.3**	5.1	9.8	**12.8**	15.7
10	2.9	**5.1**	7.4	11.7	**14.3**	16.9	7.0	**8.9**	10.8	7.1	**9.1**	11.2	10.9	**13.3**	15.6	3.5	**5.9**	8.2	5.3	**7.4**	9.6	6.5	**8.7**	11.0